

## 7. HUMAN HEALTH BASELINE RISK ASSESSMENT

This Baseline Risk Assessment (risk assessment) has been prepared by Clement International Corporation, Inc., under subcontract to ICF KE. This risk assessment was completed before the additional sampling data collected in 1991 were available. Therefore, these data were not included in the quantitative portions of the assessment. A review of the additional data and their impacts on the risk assessment was conducted. These impacts are summarized at the end of this section and discussed in greater detail in Appendix K.

### 7.1 INTRODUCTION

This risk assessment addresses the potential human health and environmental impacts associated with the Arrowhead Plating site in Montross, VA. In response to Article VII-B of the Administrative Order by Consent (Consent Order) executed by Scovill, Inc., and the Virginia Department of Waste Management (VADWM), a baseline risk assessment has been conducted. The overall goal of the risk assessment is to determine whether chemicals associated with the site pose current or potential future risks to human health or the environment. The results of the risk assessment may be used to determine whether remediation is necessary, to provide justification for performing remedial action, and to assist in determining which media need to be remediated.

This risk assessment follows EPA guidance for performing risk assessments in general (EPA 1986a,b,c,d) and for Superfund risk assessments in particular (EPA 1989a). This risk assessment was conducted using generally conservative assumptions, including the concept of "reasonable maximum exposure," as outlined by the EPA (EPA 1989a, EPA 1990b). The general purpose of using conservative assumptions is to ensure that health protective decisions will be made even in the absence of comprehensive and definitive health studies. As a result, the risks calculated in this assessment do not necessarily represent the true risks which are experienced by the exposed population, but rather represent the upper-bound risks potentially experienced by the exposed population; exposures and risks above those predicted here are highly unlikely to occur. The approach used in this assessment is compatible with EPA's policy (EPA 1990b) of protecting all members of the population, including sensitive subgroups, from adverse effects associated with exposure to hazardous chemicals.

The remainder of this risk assessment is organized as follows:

- **Section 7.2, "Selection of Chemicals of Potential Concern."** Chemicals detected in environmental media sampled during the field investigation (soil, ground water, surface water, and sediment) are identified and chemicals are selected for evaluation in the risk assessment (Section 7.5).
- **Section 7.3, "Exposure Assessment."** The pathways by which human populations may be exposed to chemicals of potential concern are identified. Exposure pathways under both current and potential future land use conditions are identified and pathways are selected for further evaluation. In addition, concentrations of chemicals in environmental media at potential exposure points are identified and

AR301441

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May 1, 1991

exposure is quantified for selected pathways. Concentration estimates are derived using available concentration data alone or in combination with models that describe the movement of chemicals in and between media.

- **Section 7.4, "Toxicity Assessment."** Chemicals of potential concern are characterized with respect to their toxic effects in humans and health effects criteria are identified.
- **Section 7.5, "Risk Characterization."** Quantitative risk estimates for human populations are derived by combining the estimated intakes (developed in Section 7.3) with the health effects criteria (identified in Section 7.4). Qualitative risk evaluations are conducted for selected pathways. The uncertainties and limitations of the risk assessment are discussed.
- **Section 7.6, "Environmental Assessment."** Risks are evaluated for non-human receptors potentially exposed to site-related chemicals. Potential receptor populations are identified, exposure is assessed, and relevant toxicity data are summarized. Then, information on exposure and toxicity is combined to evaluate potential impacts on the selected receptor species.
- **Section 7.7, "Summary and Conclusions."** The results of the risk assessment are summarized and conclusions are presented.

## 7.2 SELECTION OF CHEMICALS OF POTENTIAL CONCERN

The preceding sections of this report have discussed in detail site background information and the results of the field investigations. This information is used in this section to identify the chemicals of potential concern in each medium. Chemicals of potential concern are defined as those chemicals that are present because of past activities at the site, and therefore exclude those chemicals that are definitively associated with sampling or laboratory artifacts,<sup>1</sup> or that are present due to sources or activities unrelated to the Arrowhead Plating site. In this assessment, both organic and inorganic chemicals are considered for selection as chemicals of potential concern. In accordance with EPA guidance (EPA 1989a), all potentially site-related organic chemicals are selected as chemicals of potential concern. However, because inorganic chemicals can be present in the environment from natural sources, unrelated to the site, they are selected as chemicals of potential concern only if they are present in site-related samples at concentrations above those present in site background samples.

Background concentrations were determined from wells, soil borings, surface water, and sediment samples from upgradient locations. Statistical evaluation was not possible because sufficient numbers (three or more) of samples were not available to calculate the standard deviation needed for statistical analysis. Instead, the following procedures were followed in comparing measured on-site concentrations to background levels:

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<sup>1</sup>Data included in this section have undergone all stages of data validation, including a comparison to laboratory, field, and trip blanks.

- For media in which two background samples were available (i.e., ground water and soil borings), a chemical was considered to be within background levels if the maximum detected concentration was within the range of background concentrations.
- For media in which only one background sample was available (i.e., surface water and sediment), a chemical was considered to be within background levels if the maximum detected concentration was less than two times the background level. Although a factor of 2 is arbitrary, it is used to reflect some of the inherent variation in chemical distribution in the environment. The factor of 2 is regarded as conservative because natural variation in background concentrations can be over an order of magnitude.

Sample results are tabulated for each environmental medium sampled during the field investigation (surface soil, subsurface soil, ground water, surface water, and sediment) and are summarized by presenting the range of detected concentrations and the frequency of detection for each chemical (excluding the additional 1991 data) to provide an indication of the extent of contamination in these media.

The following steps were used to summarize sampling data for each medium.

- Chemicals that were never detected in a given medium were excluded from the data summary for that medium.
- Duplicate samples (those taken at the same location on the same day) were combined by calculating the arithmetic average of the two sample concentrations.
- Round 1 and Round 2 data from any given sampling point were combined by taking the arithmetic average of the two sample concentrations.
- To calculate the arithmetic average for a data pair (i.e., duplicates, or Round 1 and 2 data), in which the chemical was detected in only one member of the sample pair, one-half of the sample quantitation limit (SQL) was used for non-detected chemical concentration. If an SQL was not available, one-half of the Contract Laboratory Program quantitation limit (CRQL) was used instead. If a chemical was detected in only one member of a sample pair to be averaged, the average of the two numbers was labeled as a detect. Sample-specific detection limits which exceeded two times the maximum detected value for a given chemical in a given medium were excluded from arithmetic average calculations. This was done to prevent the mean from being artificially biased upwards by high detection limits.

Summarized data are discussed below by medium. Section 3 of this report should be consulted for an identification of sample locations within each medium.

### 7.2.1 Surface Soil

One round of surface soil (0-6 in.) samples was collected from 20 locations on the site and analyzed for volatile organic compounds (VOC), base neutral acids (BNA), and inorganic chemicals. Eight samples were collected around the former drum storage areas east and north of the existing

A.R. Winarick facility, four samples were collected surrounding the above-ground acid tanks located north of the building, four samples were collected around the above-ground chlorinated solvent tank near the northwest corner of the building, three samples were collected from the drain lines which drain from the site into Scates Branch, and one composite sample was collected from an area of stained soil (SP1) located near the large drum storage area.

Chemicals detected in the surface soil are shown in Table 7-1 (excluding the additional 1991 data), along with the frequency of detection, range of detection limits, and range of detected concentrations. Table 7-1 also presents background concentrations for soils of the area. Because no site-specific background surface soil samples were available, chemical concentrations in subsurface soil from background areas (SB1 and SB3) were used to evaluate the site-relatedness of inorganic chemicals in surface soils. An inorganic chemical was considered site related if its surface soil concentration was above the range of background concentrations reported from subsurface soil. Organic chemicals that were detected in a given area, and inorganic chemicals whose concentrations are considered significantly greater than background levels are identified by an asterisk as chemicals of potential concern in that area.

Sampling data for surface soil are discussed below by sampling location. Separate discussions are presented because each sampling location represents a distinct source area; evaluating them separately will facilitate in the determination of the need to remediate the individual source areas.

**Drum Storage Areas.** Three drum storage areas were sampled. Several volatile and semi-volatile (phthalates) chemicals were detected in these areas. With the exception of acetone, which was detected in three of eight samples, all organic chemicals were detected infrequently (one of eight samples) and at generally low concentrations. Acetone, bis(2-ethylhexyl)phthalate, and carbon tetrachloride were detected at concentrations at or near the detection limit, and methylene chloride was detected at a concentration below the detection limit. All organic chemicals, although present infrequently and at low concentrations, are selected as chemicals of potential concern for the drum storage areas.

Inorganic chemicals, with the exception of iron, were present at concentrations above background concentrations and therefore are selected as chemicals of potential concern for the drum storage area.

**Acid Tank Area.** Acetone, methyl ethyl ketone (2-butanone), and bis(2-ethylhexyl)phthalate were the only organic chemicals detected in the acid tank area. Acetone and methyl ethyl ketone were detected in one of four samples (SS35) and bis(2-ethylhexyl)phthalate was detected in two of the four samples (SS32 and SS33). The detected concentrations of these chemicals are low, with the reported concentration of methyl ethyl ketone near the detection limit and that of bis(2-ethylhexyl)phthalate below the detection limit. These chemicals are nevertheless selected as chemicals of potential concern. Inorganic chemicals, with the exception of iron, were detected at concentrations above background concentrations and therefore are selected as chemicals of potential concern for the acid tank area.

**Solvent Tank Area.** Tetrachloroethene was detected in all 4 samples collected in this area with a maximum concentration of 3,300 g/kg. Acetone and 1,1,1-trichloroethane were detected in one sample each (SS36 and SS37, respectively) at concentrations of 3,200 and 20 µg/kg, respectively. Phenanthrene, a polycyclic aromatic hydrocarbon (PAH), was detected once (SS36) at a reported concentration below the quantification limit. All organic chemicals are selected as chemicals of

TABLE 7-1

SUMMARY OF CHEMICALS DETECTED IN  
SURFACE SOIL AT THE ARROWHEAD PLATING SITE  
(Concentrations reported as ug/kg for organic and mg/kg for inorganic chemicals)

Area/ Chemical	Frequency of Detection (a)	Range of Detection Limits	Range of Detected Concentrations	Range of Background Concentrations (b)
<b>Drum Storage Areas (c)</b>				
Organics:				
* Acetone	3/8	11 - 12	11 - 50	ND (11 - 14)
* Bis(2-ethylhexyl)phthalate	1/8	270 - 390	310	ND (380 - 470)
* Carbon tetrachloride	1/8	6	6	ND
* Di-n-butylphthalate	1/8	370 - 770	490	ND
* Methyl ethyl ketone	1/8	11 - 12	21	ND (11 - 14)
* Methylene chloride	1/8	6	4	ND (6 - 7)
* Tetrachloroethene	1/8	6	97	ND (6 - 7)
* 1,1,1-Trichloroethane	1/8	6	32	ND
* Trichloroethene	1/8	6	29	ND
Inorganics:				
* Aluminum	8/8	80	4,300 - 9,800	2300 - 4500
* Barium	8/8	80	19 - 51	8.4 - 8.5
* Calcium	8/8	2,000	500 - 19,000	15 - 25
* Chromium	8/8	4	6.8 - 12	3.9 - 7
* Copper	6/8	10 - 13	32 - 180	3.7 - 4.5
* Cyanide	7/8	0.5	0.6 - 8.7	ND (0.36 - 0.4)
* Iron	8/8	40	5,000 - 11,000	21,000 - 27,000
* Lead	5/8	4.9 - 8.6	5.2 - 9	ND (4.5 - 4.8)
* Nickel	8/8	16	2.4 - 6.3	3.1 - 3.2
* Potassium	8/8	2,000	170 - 860	ND (104 - 200)
* Silver	1/8	0.3 - 0.4	0.7	ND (0.33)
* Sodium	8/8	2,000	53 - 340	ND (14 - 17)
* Zinc	8/8	8	15 - 77	7.2 - 9.7
<b>Acid Tank Area (d)</b>				
Organics:				
* Acetone	1/4	8 - 12	98	ND (11 - 14)
* Bis(2-ethylhexyl)phthalate	2/4	370 - 390	190 - 200	ND (380 - 470)
* Methyl ethyl ketone	1/4	11 - 12	16	ND (11 - 14)
Inorganics:				
* Aluminum	4/4	80	1,000 - 15,000	2300 - 4500
* Barium	4/4	80	18 - 68	8.4 - 8.5
* Calcium	4/4	2,000	100 - 1,900	15 - 25
* Chromium	4/4	4	3 - 19	3.9 - 7
* Copper	2/4	2.7 - 11	35 - 37	3.7 - 4.5
* Cyanide	1/4	0.5 - 0.6	0.7	ND (0.36 - 0.4)
* Iron	3/3	40	560 - 16,000	21,000 - 27,000
* Lead	3/4	4.6	6.6 - 10	ND (4.5 - 4.8)
* Mercury	1/4	0.1 - 0.1	0.2	ND (0.11)
* Nickel	3/4	1.3	2.5 - 9.5	3.1 - 3.2
* Potassium	4/4	2,000	150 - 520	ND (104 - 200)
* Sodium	4/4	2,000	30 - 95	ND (13.6 - 16.5)
* Zinc	4/4	8	1.9 - 51	7.2 - 9.7
<b>Solvent Tank Area (e)</b>				
Organics:				
* Acetone	1/4	11 - 60	3,200	ND (11 - 14)
* Phenanthrene	1/4	660	140	ND
* Tetrachloroethene	4/4	10	19 - 3,300	ND (6 - 7)
* 1,1,1-Trichloroethane	1/4	6	20	ND
Inorganics:				
* Aluminum	4/4	80	5,800 - 8,500	2,300 - 4,500
* Barium	4/4	80	37 - 140	8.4 - 8.5
* Cadmium	1/4	0.6 - 0.6	1.0	ND (0.54)
* Calcium	4/4	2,000	600 - 4200	15 - 25
* Chromium	4/4	4	7.7 - 13	3.9 - 7
* Copper	3/4	8.3	31 - 7,800	3.7 - 4.5
* Iron	4/4	40	6,900 - 12,000	21,000 - 27,000
* Lead	4/4	1.2	6.9 - 19	ND (4.5 - 4.8)
* Mercury	1/4	0.1	6.4	ND (0.11)
* Nickel	4/4	16	2.5 - 15	3.1 - 3.2
* Potassium	4/4	2,000	200 - 310	ND (104 - 200)
* Silver	1/4	0.3 - 0.3	0.5	ND (0.33)
* Sodium	4/4	2,000	39 - 140	ND (13.6 - 16.5)
* Zinc	4/4	8	12 - 860	7.2 - 9.7

TABLE 7-1 (Continued)

SUMMARY OF CHEMICALS DETECTED IN  
SURFACE SOIL AT THE ARROWHEAD PLATING SITE

(Concentrations reported as ug/kg for organic and mg/kg for inorganic chemicals)

Area/ Chemical	Frequency of Detection (a)	Range of Detection Limits	Range of Detected Concentrations	Range of Background Concentrations (b)
<b>Drain Lines Area (f)</b>				
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Inorganics:				
* Aluminum	3/3	80	8,700 - 11,000	2,300 - 4,500
* Barium	3/3	80	30 - 35	8.4 - 8.5
* Calcium	3/3	2,000	100 - 300	15 - 25
* Chromium	3/3	4	10 - 13	3.9 - 7
* Copper	3/3	10	4.3 - 5.1	3.7 - 4.5
* Iron	3/3	40	8,400 - 14,000	21,000 - 27,000
* Lead	3/3	1.2	6 - 8.2	ND (4.5 - 4.8)
* Mercury	1/3	0.1 - 0.1	0.1	ND (0.11)
* Nickel	3/3	16	4.5 - 5.6	3.1 - 3.2
* Potassium	3/3	2,000	320 - 400	ND (104 - 200)
* Sodium	3/3	2,000	16 - 44	ND (14 - 17)
* Zinc	3/3	8	13 - 15	7.2 - 9.7
<b>Stained Area (g)</b>				
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Organics:				
* Bis(2-ethylhexyl)phthalate	1/1	10	1,200	ND (380 - 470)
* 1,2-Dichloroethene (total)	1/1	5	580	ND (6 - 7)
* Tetrachloroethene	1/1	10	150	ND (6 - 7)

(a) The number of samples in which the chemical was detected divided by the total number of samples analyzed.

(b) No surface soil background concentrations were available. Therefore, background concentrations obtained from subsurface soil samples (SB1 and SB3) are reported here.

(c) Samples: SS21 - SS28.

(d) Samples: SS32 - SS35.

(e) Samples: SS36 - SS39.

(f) Samples: SS29 - SS31.

(g) Sample: SP1. Sample analyzed for organic chemicals only.

\* = Chemical of potential concern.

ND = Not detected. Detection limits given in parentheses if available.

potential concern. In addition, all inorganic chemicals with the exception of iron were detected at concentrations above background and therefore are selected as chemicals of potential concern for the solvent tank area.

**Drain Lines.** No VOCs and BNAs were detected in any of the three drain line samples. However, all of the inorganic chemicals with the exception of iron were detected at concentrations above background and are selected as chemicals of potential concern.

**Stained Area.** The composite sample taken from the stained area (SP1) was analyzed only for organic chemicals. Tetrachloroethene, 1,2-dichloroethene, and bis(2-ethylhexyl)phthalate were the only organic chemicals detected and are selected as chemicals of potential concern for the stained area.

### 7.2.2 Subsurface Soil

Subsurface soil samples were collected from 13 soil borings obtained during monitoring well installation, including borings from on-site background locations (SB1 and SB3) and analyzed for VOCs, BNAs, and inorganic chemicals. Six additional borings from the old pond and sludge storage pond areas (SB15-SB20) were analyzed for copper, zinc, cyanide and organic chemicals. These three inorganic chemicals were associated with past activities at the site and were detected at high concentrations in the drum storage and pond areas prior to the Immediate Removal Actions conducted in 1986-1990.

The chemicals detected in subsurface soil samples are presented in Table 7-2 (with the exception of the additional 1991 data) along with the frequency of detection, range of detection limits, range of on-site concentrations, and range of background concentrations. Chemical concentrations were averaged across depth within a soil boring before being summarized along with other data from across the site. No concentration trends with respect to depth were observed, and therefore data were not summarized with respect to depth. Six VOCs and two BNAs were detected in subsurface soil samples. Acetone and tetrachloroethene were each detected at 3 of 12 sample locations. Methyl ethyl ketone (2-butanone), methylene chloride, toluene, and xylenes were each detected once. 4-Chloro-aniline and bis(2-ethylhexyl)phthalate, both BNAs, were each detected only once. 4-Chloro-aniline was not detected in any other media at the site. All organic chemicals detected in subsurface soils are selected as chemicals of potential concern.

Twelve inorganic chemicals were detected in subsurface soil. Five of the twelve inorganic chemicals (aluminum, copper, nickel, potassium, and zinc) were detected in all samples analyzed. In the six additional samples analyzed for only copper, zinc, and cyanide, copper and zinc were detected in all samples, and cyanide was detected in five of the six samples.

All inorganic chemicals detected in subsurface soils are selected as chemicals of potential concern because they were present at levels that exceeded the range of background concentrations.

### 7.2.3 Ground Water

Groundwater samples were collected from 16 monitoring wells, including 2 on-site background wells (MW1 and MW3), and analyzed for VOCs, BNAs, and inorganic chemicals. With the exception of the wells AR-1, AR-2, and AR-3, two rounds of samples were collected and analyzed for VOCs, BNAs, and inorganic chemicals. Data from Round 1 and Round 2 were averaged for each well

TABLE 7-2

SUMMARY OF CHEMICALS DETECTED IN  
SOIL BORINGS AT THE ARROWHEAD PLATING SITE

(Concentrations reported as ug/kg for organic and mg/kg for inorganic chemicals)

Chemical	Frequency of Detection (a)	Range of Detection Limits	Range of Detected On-site Concentrations (b)	Range of Background Concentrations (c)
<b>Organics:</b>				
* Acetone	3/12	11 - 16	12 - 5,600	ND (11 - 14)
* Bis(2-ethylhexyl)phthalate	1/11	360 - 380	210	ND (380 - 470)
* 4-Chloroaniline	1/11	360 - 840	515	ND (380 - 470)
* Methyl ethyl ketone	1/12	11 - 16	13	ND (11 - 14)
* Methylene chloride	1/12	5 - 8	10.5	ND (6 - 7)
* Tetrachloroethene	3/12	5 - 11	8 - 70,000	ND (6 - 7)
* Toluene	1/12	5 - 5.5	3	ND (6 - 7)
* Xylenes (total)	1/12	5 - 6	4	ND (6 - 7)
<b>Inorganics:</b>				
* Aluminum	11/11	80	3,600 - 8,300	2,300 - 4,500
* Barium	5/11	9.5 - 44	12 - 33	8.4 - 8.5
* Calcium	5/11	100 - 450	18 - 10,000	15 - 25
* Chromium	5/11	6.2 - 18.4	5.5 - 23	3.9 - 7
* Copper	17/17	10	1.4 - 330	3.7 - 4.5
* Cyanide	6/17	0.3 - 0.7	0.2 - 1.1	ND (0.36 - 0.4)
* Iron	5/11	9,690 - 54,100	9,900 - 73,000	21,000 - 27,000
* Lead	5/11	3.1 - 5.6	4.2 - 9.7	4.8
* Nickel	11/11	16	1.4 - 5.4	3.1 - 3.2
* Potassium	11/11	2,000	160 - 1,100	198
* Sodium	4/11	14.8 - 575	82 - 500	(d)
* Zinc	17/17	8	5.2 - 91	7.2 - 9.7

(a) The number of soil boring locations at which the chemical was detected divided by the total number of soil boring locations for which samples were analyzed.

(b) Samples: SB2, SB4 - SB13, SB20.

(c) Samples: SB1 and SB3.

(d) Sodium was reported in the blank at concentrations higher than those reported in the background samples. Therefore, the actual concentrations in the background sample are unknown.

\* = Chemical of potential concern.

ND = Not detected. Detection limits given in parentheses.

TABLE 7-3  
SUMMARY OF CHEMICALS DETECTED IN  
GROUND WATER AT THE ARROWHEAD PLATING SITE  
(Concentrations in ug/L)

Chemical	Frequency of Detection (a)	Range of Detection Limits	Range of Detected On-Site Concentrations (b)	Range of Background Concentrations (c)
<b>Organics:</b>				
* Acetone	3 / 14	7.5 - 2,500	12 - 780	ND (7.5) - 96
* Chloroform	1 / 14	5	9.8	ND (5 - 15)
* 1,1-Dichloroethane	1 / 14	5 - 7.5	42	ND (5 - 15)
* 1,1-Dichloroethene	7 / 14	5 - 750	4.5 - 6,200	ND (5 - 15)
* 1,2-Dichloroethene (total)	3 / 14	5 - 2,500	79 - 4,400	ND (5 - 15)
* Methylene Chloride	3 / 14	5 - 100	3.3 - 180	3.8
* Tetrachloroethene	11 / 14	5	19 - 16,000	ND (5 - 15)
* 1,1,1-Trichloroethane	9 / 14	5	4.5 - 90,000	ND (5 - 15)
* Trichloroethene	10 / 14	5 - 2,500	3 - 4,500	ND (5 - 15)
<b>Inorganics:</b>				
* Aluminum	14 / 14	400	2,200 - 55,000	3,600 - 5,700
* Barium	14 / 14	400	26 - 230	40 - 77
* Cadmium	3 / 14	3 - 5	4.1 - 7.6	ND (4.5 - 5)
* Calcium	14 / 14	10,000	2,600 - 150,000	4,200 - 23,000
* Chromium	14 / 14	20	3.8 - 79	5.1 - 14
* Copper	14 / 14	50	2.3 - 9,100	4.1 - 4.5
* Cyanide	5 / 14	5 - 10	11 - 78	ND (5 - 10)
* Iron	14 / 14	200	6,900 - 110,000	6,700 - 10,000
* Lead	14 / 14	6	2 - 40	3.2 - 4.7
* Mercury	1 / 14	0.2	0.2	ND (0.2)
* Nickel	8 / 14	5 - 11	7.5 - 540	10.4
* Potassium	14 / 14	10,000	1,200 - 13,000	1,700 - 3,000
* Silver	2 / 14	1	0.8 - 0.9	ND (1)
* Sodium	14 / 14	10,000	5,500 - 250,000	6,900 - 24,000
* Zinc	14 / 14	40	18 - 4,100	11 - 38

(a) The number of wells in which the chemical was detected divided by the total number of wells sampled.

(b) Samples: MW2, MW4 - MW13, AR1 - AR3.

(c) Samples: MW1 and MW3.

\* = Chemical of potential concern.

ND = Not detected. Detection limits given in parentheses. Value shown is arithmetic mean of Round 1 and Round 2 detection limits.

before being summarized with other data from across the site. The chemicals detected in ground water are summarized in Table 7-3 (with the exception of the 1991 data). Copper and zinc were detected in all wells, and cyanide was detected in 5 of 14 wells. All organic and inorganic chemicals detected in ground water are selected as chemicals of potential concern.

No BNAs were detected in any of the samples. VOCs, particularly halogenated aliphatic hydrocarbons, were present in 13 of 14 wells, as were the majority of the inorganic chemicals. Tetrachloroethene and trichloroethene were the most frequently detected VOCs, being detected in 11 and 10 wells, respectively, of the total of 14 wells sampled.

Acetone and methylene chloride were detected in both upgradient and downgradient wells. Concentrations of these two chemicals were compared against concentrations in the blanks as part of the standard QA/QC procedures; because the concentrations were significantly higher than concentrations in the blank, they are reported as detected and are included as chemicals of potential concern.

The halogenated organic chemicals detected in ground water may have been used as solvents at the Arrowhead Plating site or may have been present as impurities in solvents used at the site. In ground water, chlorinated organic chemicals such as tetrachloroethene and 1,1,1-trichloroethane are transformed over time by reductive dechlorination. Trichloroethene and 1,2-dichloroethene, both products of reductive dechlorination, are present in ground water, suggesting that this process may be occurring in ground water at the site.

Vinyl chloride, one of the ultimate products of reductive dechlorination, was not present in any of the initial groundwater samples at detectable levels. However, the groundwater samples had to be diluted to obtain quantifiable concentrations of some of the VOCs and the resulting sample quantitation (detection) limits for vinyl chloride range from 10 to 20,000  $\mu\text{g/L}$ . In the additional 1991 sampling, vinyl chloride was detected in 5 of 20 samples at concentrations ranging from 2 to 10  $\mu\text{g/L}$ . See Appendix K for impacts to risk assessment.

#### 7.2.4 Surface Water

Surface water in the immediate vicinity of the site consists of Scates Branch, its tributary streams, and Weavers Mill pond. Scates Branch originates at the northeast corner of the site and flows in a northeasterly direction for approximately one mile, where it enters Weavers Millpond. Two rounds of surface water samples were obtained from seven locations (ST1 to ST7) in nearby surface water and analyzed for VOCs, BNAs, and inorganic chemicals. ST1 was located on Scates Branch immediately northeast of the site. ST2 and ST3 were located downstream on Scates Branch before the millpond. ST4, considered to be a background sample, was located on an unnamed branch that joins Scates Branch downstream of ST3. ST5 was on Scates Branch below this junction, ST6 was at the inflow to Weavers Millpond, and ST7 was located at Weavers Millpond near its outflow into Pierce Creek. Table 7-4 summarizes surface water sampling data (excluding additional 1991 data). Inorganic chemical concentrations are reported as total concentrations.

VOCs were detected only in ST1 and ST2, the two sample points located nearest to the site and not in samples collected further downstream suggesting that surface water transport of these chemicals is limited by volatilization. Bis(2-ethylhexyl)phthalate was the only BNA detected in surface water. It was detected only in Round 1, at a concentration of 18  $\mu\text{g/L}$ . All VOCs detected in the

TABLE 7-4  
SUMMARY OF CHEMICALS DETECTED IN  
SURFACE WATER AT THE ARROWHEAD PLATING SITE  
(Concentrations in ug/L)

Chemical	Frequency of Detection (a)	Range of Detection Limits	Range of Detected On-Site Concentrations (b)	Background Concentrations (c)
Organics:				
* Bis(2-ethylhexyl)phthalate	1 /6	10 - 14	12	ND (9.5)
* 1,2-Dichloroethene (total)	2 /6	5	5.3 - 25	ND (5)
* Tetrachloroethene	2 /6	5	7.5 - 38	ND (5)
* Trichloroethene	2 /6	5	6.5 - 34	ND (5)
Inorganics (d):				
* Aluminum	6 /6	400	280 - 2,400	380
Barium	6 /6	400	24 - 87	59
Cadmium	2 /6	3.5	5.2 - 5.3	4.7
* Calcium	6 /6	10,000	3,400 - 20,000	3,600
Chromium	1 /6	7 - 7.4	5.9	4.8
* Copper	6 /6	50	1.2 - 11	1.3
* Cyanide	1 /6	10	16	ND (10)
* Iron	6 /6	200	2,600 - 6,200	1,400
Lead	2 /6	1 - 2.1	0.8 - 1.8	1.1
* Potassium	6 /6	10,000	2,300 - 7,900	2,900
* Sodium	6 /6	10,000	4,400 - 110,000	9,800
Zinc	6 /6	40	7.5 - 15	15

(a) The number of locations at which the chemical was detected divided by the total number of locations sampled.

(b) Samples: ST1 - ST3, ST5 - ST7.

(c) Sample: ST4.

(d) Total concentrations reported.

\* = Chemical of potential concern.

ND = Not detected. Detection limit given in parentheses. Value shown is arithmetic mean of Round 1 and Round 2 detection limits.

Scates Branch, and bis(2-ethylhexyl) phthalate, are selected as chemicals of potential concern in surface water.

Of the inorganic chemicals detected, all except barium, cadmium, chromium, lead, and zinc were detected at concentrations above background and are chosen as chemicals of potential concern. No chemical distribution trend was observed for inorganic chemicals.

### 7.2.5 Sediment

Sediment samples were collected from the same locations as surface water samples (ST1-ST7) and analyzed for VOCs, BNAs, and inorganic chemicals. Table 7-5 summarizes sediment sampling data (excluding 1991 data). VOCs were detected only in ST1, and only in the first of the two sampling rounds. Acetone, methyl ethyl ketone (2-butanone), benzoic acid, and bis(2-ethylhexyl) phthalate are the BNAs detected in sediment. All VOCs and BNAs detected in sediment are chosen as chemicals of potential concern. Of the inorganic chemicals detected in sediment, only calcium, nickel and sodium were detected at concentrations above background concentrations; these inorganic chemicals also are selected as chemicals of potential concern in sediment.

### 7.2.6 Summary of Chemicals of Potential Concern

Table 7-6 presents the chemicals of potential concern for each medium. As shown in this table, ground water contains the highest number of the chemicals of potential concern followed by surface soil. Volatile organic chemicals comprise the majority of the organic chemicals of potential concern; these chemicals were detected in all media sampled at the site. All media contain a large number of inorganic chemicals of potential concern. Although, it is possible that all these inorganic chemicals are site-related, it is most likely that some are within true background levels but could not be eliminated from evaluation based on the few background samples collected at the site.

## 7.3 EXPOSURE ASSESSMENT

In this section, the potential pathways by which human populations may be exposed to the chemicals of potential concern are identified and exposure is quantified. In Section 7.3.1, potential exposure pathways under both current and future land-use conditions are discussed and exposure pathways are selected for further evaluation. In Section 7.3.2, the chemical concentrations at the exposure points are calculated for each pathway selected for quantitative evaluation. Then the magnitude, frequency, and duration of exposure are estimated and exposures (intakes) are quantified. It should be noted that this quantitative analysis does not include the 1991 sampling data. See Appendix K for impacts to the risk assessment.

### 7.3.1 Potential Exposure Pathways

An exposure pathway describes the course a chemical takes from the source to the exposed individual. An exposure pathway generally consists of four elements:

- A source and mechanism of chemical release;
- A receiving and/or transport medium;

TABLE 7-5

SUMMARY OF CHEMICALS DETECTED IN  
SEDIMENT AT THE ARROWHEAD PLATING SITE

(Concentrations reported as ug/kg for organic chemicals and mg/kg for inorganic chemicals)

Chemical	Frequency of Detection (a)	Range of Detection Limits	Range of Detected On-Site Concentrations (b)	Background Concentrations (c)
<b>Organics:</b>				
* Acetone	3 / 6	13 - 14	9.3 - 68	15
* Benzoic acid	2 / 6	3,200	500 - 730	ND (2,400)
* Bis(2-ethylhexyl)phthalate	2 / 6	440 - 530	200 - 430	ND (495)
* 1,2-Dichloroethene (total)	1 / 6	6.5 - 8	4.6	ND (7.5)
* Methyl ethyl ketone	1 / 6	13 - 14	14	ND (15)
* Tetrachloroethene	1 / 6	6.5 - 8	10.6	ND (7.5)
* Trichloroethene	1 / 6	6.5 - 8	5.1	ND (7.5)
<b>Inorganics:</b>				
Aluminum	6 / 6	80	750 - 16,000	10,000
Barium	6 / 6	80	5.8 - 105	58
Cadmium	4 / 6	0.4 - 0.4	0.4 - 0.6	0.4
* Calcium	6 / 6	2,000	100 - 680	250
Chromium	6 / 6	4	3.8 - 17	24
Copper	6 / 6	10	1.6 - 7.1	5.3
Iron	6 / 6	40	3,300 - 3,000	12,000
Lead	6 / 6	1.2	1.7 - 7.6	7
* Nickel	4 / 6	1.8 - 1.9	2.6 - 9.2	2.5
Potassium	6 / 6	2,000	270 - 930	1,600
Silver	5 / 6	0.3	0.3 - 0.8	0.4
* Sodium	6 / 6	2,000	22 - 150	65
Zinc	6 / 6	8	6.3 - 35	20

(a) The number of locations at which the chemical was detected divided by the total number of locations sampled.

(b) Samples: SD1 - SD3, SD5 - SD7.

(c) Sample: SD4.

\* = Chemical of potential concern.

ND = Not detected. Detection limits given in parentheses. Value shown is the arithmetic mean of Round 1 and Round 2 detection limits.

TABLE 7-6  
SUMMARY OF CHEMICALS OF POTENTIAL CONCERN FOR THE ARROWHEAD PLATING SITE

Chemical	Surface Soil					Sub-Surface Soil	Ground Water	Surface Water	Sediment
	Drum Storage Areas	Acid Tank Area	Solvent Tank Area	Drain Lines Area	Stained Area				
Organics:									
Acetone	X	X	X			X	X		X
Benzoic acid									X
Bis(2-ethylhexyl)phthalate	X	X			X			X	X
Carbon tetrachloride	X					X			
4-Chloroaniline						X			
Chloroform							X		
1,1-Dichloroethane							X		
1,1-Dichloroethene							X		
1,2-Dichloroethene (total)					X		X	X	X
Di-n-butylphthalate	X								
Methyl ethyl ketone	X	X				X			X
Methylene chloride	X					X	X		
Phenanthrene			X						
Tetrachloroethene	X		X		X	X	X	X	X
Toluene						X			
1,1,1-Trichloroethane	X		X				X		
Trichloroethene	X						X	X	X
Xylenes (total)						X			
Inorganics:									
Aluminum	X	X	X	X		X	X	X	
Barium	X	X	X	X		X	X		
Cadmium			X				X		
Calcium	X	X	X	X		X	X	X	X
Chromium	X	X	X	X		X	X		
Copper	X	X	X	X		X	X	X	
Cyanide	X	X				X	X	X	
Iron						X	X	X	
Lead	X	X	X	X		X	X		
Mercury (inorganic)		X	X	X			X		
Nickel	X	X	X	X		X	X		X
Potassium	X	X	X	X		X	X	X	
Silver	X		X				X		
Sodium	X	X	X	X		X	X	X	X
Zinc	X	X	X	X		X	X		

X = Selected as a chemical of potential concern in this medium.

- A point of potential contact with the contaminated medium; and
- An exposure route (e.g., ingestion) at the contact point.

A pathway is considered complete only if all these elements are present. Only complete pathways are evaluated in risk assessments. The first two elements of a complete exposure pathway have been discussed in previous sections of this report. In this section, information regarding the sources and fate and transport of chemicals at the Arrowhead Plating site is combined with information on population locations, activity patterns, and land use to define exposure pathways. Potential exposure pathways under both current and hypothetical future use of the site and surrounding area are discussed below and then the pathways selected for evaluation are summarized.

#### ***7.3.1.1 Potential Exposure Pathways Under Current Land-Use Conditions***

The Arrowhead Plating site is a currently operating facility located in a rural area in eastern Virginia. Properties neighboring the facility include a truck repair garage and lumber yard to the north, Chandler's Chevrolet dealership to the south, and agricultural land to the east and west. The closest town is Montross, located approximately 2 miles northwest of the site, with a population of approximately 500. Montross is characterized as a rural agricultural town with a small industrial base. Land use within a mile of the site is predominantly farmland or undeveloped open fields and woodlands.

The primary human receptor populations of concern are the employees of A.R. Winarick Company and Mattatuck Manufacturing Company who work in the manufacturing building on site. No residents live on land adjacent to the site and given that the closest residential development is a mile away, trespassing is not likely to be common. Further, no public or private recreation areas exist in the immediate vicinity. Potential exposure pathways for these worker populations are discussed below for each medium for which chemicals of potential concern were selected.

**Soil. Surface Soil.** Workers at the site could be exposed to chemicals in surface soil by direct contact with chemicals in surface soil, and by inhalation of chemicals volatilizing from soil or sorbed to airborne soil particulates.

However, direct contact exposures are likely to be negligible given that the employees work almost exclusively inside the manufacturing building and that typical outside activities (e.g., unloading supplies, trips to and from parked vehicles) are of brief duration and do not involve extensive contact. Therefore, direct contact with surface soils under current land-use conditions will not be evaluated in this assessment.

Volatilization of chemicals in surface soil could result in potential worker exposures via inhalation. Because volatile chemicals could be transported indoors where workers spend most of their time, exposures of relatively long duration (8 hr/day) are possible. Therefore, this exposure pathway will be evaluated quantitatively.

Generation of airborne particulates containing chemicals from surface soil also could result in potential worker exposures via inhalation. However, the surface soil areas are for the most part

either vegetated<sup>2</sup> or compacted and covered with gravel, and dust entrainment from such areas is not likely to be as significant an exposure pathway as volatilization of chemicals from surface soil. Therefore, this exposure pathway will not be evaluated.

**Subsurface Soil.** Direct contact with chemicals in subsurface soil could occur if deeper soils were excavated or graded as part of some construction activity at the facility. However, such exposures would be of very short duration and consequently are unlikely to result in significant exposures. Therefore, direct contact with chemicals in subsurface soils will not be evaluated in this assessment.

**Ground Water.** Ground water is not currently used at the site for drinking water. However, ground water is the source of drinking water for all residents in the area. However, all private water supply wells identified within a three mile radius of the site are upgradient or crossgradient, and therefore would not be impacted by the site. Neither ground water nor surface water are used for irrigation in the vicinity of the site. Under the current land use conditions, a point of contact does not exist for the groundwater pathway. Therefore exposure to chemicals in ground water will not be assessed under current land use conditions.

**Surface Water and Sediment.** It is unlikely that individuals will be exposed to chemicals in the surface water (or volatilization of VOCs from the water) due to the isolation of the site from residential areas. The individuals most likely to be exposed to chemicals in surface water at the site are children who may wade or otherwise play in the water. The area is not very accessible to children, as there are no residences, playgrounds, schools, or other such areas nearby. Therefore exposure to chemicals in surface water under current land use conditions will not be quantified.

Ingestion of fish in Scates Branch that have accumulated chemicals present in surface water is not likely because given the extremely shallow nature of Scates Branch (e.g., about 3-4 in. deep<sup>3</sup>) it is unlikely to support sport fish populations. Sport fish populations could exist in Weavers Millpond. However, none of the chemicals detected in or near Weavers Millpond (at ST6 and ST7) are likely to accumulate appreciably in fish given their low concentrations (e.g., generally <1 mg/L) and their low potential for significant bioaccumulation in fish (bioconcentration factors range from 1 [copper, EPA 1985a] to 136 [aluminum, EPA 1988a]). Also, Weavers Millpond is not easily accessible to the public since the only road leading to the millpond, which is located on private property, has a gate which is usually locked. Therefore, exposures via ingestion of fish caught from Weavers Millpond are likely to be negligible and will not be evaluated in this assessment.

#### **7.3.1.2 Potential Exposure Pathways Under Future Land-Use Conditions**

It is possible that in the future, the Arrowhead Plating site could be sold and redeveloped as a residential area, potentially resulting in residential exposures to chemicals in soil, ground water, surface water, and sediment. Although residential development of the site is probably not likely, it will be evaluated in this assessment to provide an upper-bound estimate of potential risks associated with alternate future use of the site. Potential exposure pathways for future residents under this scenario are discussed below.

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<sup>2</sup>The waste water and sludge storage ponds have recently been reseeded and will be maintained with a permanent vegetative cover.

<sup>3</sup>Observed during ICF site visit on April 4, 1990.

**Soil.** Future residents located at the current site could be exposed to chemicals in surface soil via direct contact with subsequent dermal absorption and incidental ingestion or via inhalation of chemicals that have volatilized from surface soil and therefore, these exposure pathways will be quantitatively evaluated in this assessment. Inhalation exposures to chemicals or wind-blown dust are not considered likely because the site is likely to remain vegetated (e.g., for lawns) or paved (e.g., for driveways) if it is developed in the future for residential use.

**Ground Water.** It is possible that future residents of the site could use groundwater from the site as a source of drinking water and could be exposed to chemicals in ground water via ingestion. This pathway will be evaluated quantitatively.

Individuals using ground water for tap water also could be exposed to chemicals via dermal absorption or via inhalation of chemicals that volatilize during use. Exposures via these pathways could be equal to those from ingestion of ground water, and therefore a qualitative evaluation of risks to future residents exposed via dermal absorption and inhalation of chemicals that volatilize from tap water will be included.

**Surface Water.** Scates Branch, the nearest surface water body, is too shallow for individuals to swim in and does not support sport fish populations, and therefore adults and teens from future residences are not likely to engage in activities which would result in exposure to chemicals in surface water. However, younger children (who could reside on the Arrowhead Plating Site under future land-use conditions), could wade in Scates Branch while playing. These children could potentially be exposed to chemicals in surface water by dermal contact (incidental ingestion would be negligible while wading) and therefore dermal contact with chemicals in surface water will be evaluated quantitatively in this assessment.

**Sediment.** Children also may be exposed to chemicals in sediments by dermal contact and incidental ingestion. Dermal contact with chemicals in sediment will also be evaluated quantitatively.

### **7.3.1.3 Summary of Exposure Pathways Selected for Evaluation**

Table 7-7 summarizes the exposure pathways selected for quantitative or qualitative evaluation in this assessment.

### **7.3.2 Quantification of Exposure**

In this section, exposures are estimated for all pathways selected for quantitative evaluation. To quantitatively assess exposures, the chronic or subchronic<sup>4</sup> daily intake of the chemicals of potential concern in each medium is estimated. Chronic daily intakes (CDIs) and subchronic daily intakes (SDIs) are expressed as the amount of a substance taken into the body per unit body weight per unit time, or mg/kg-day. CDIs and SDIs are averaged over a lifetime for carcinogens and over the exposure period for noncarcinogens. CDIs and SDIs are estimated using chemical exposure point concentrations together with other parameters that describe the frequency, duration, and magnitude of exposure.

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<sup>4</sup>According to EPA (1989a) guidance, chronic exposures are defined as exposures of 7 yr or more in duration, and subchronic exposures are defined as exposures between 2 wk and 7 yr.

TABLE 7-7

## EXPOSURE PATHWAYS SELECTED FOR EVALUATION AT THE ARROWHEAD PLATING SITE

Exposure Medium	Potentially Exposed Population	Exposure Route	Type of Evaluation
<b>Current Land Use</b>			
Air	Workers	Inhalation of chemicals that volatilize from soil into ambient air.	Quantitative
<b>Future Land Use</b>			
Air	Residents	Inhalation of chemicals that volatilize from soil into ambient air.	Quantitative
Soil	Residents	Incidental ingestion of chemicals in soil.	Quantitative
	Residents	Dermal contact with chemicals in soil.	Quantitative
Ground Water	Residents	Ingestion of chemicals in ground water.	Quantitative
	Residents	Dermal contact with chemicals in ground water during in-house use.	Qualitative
	Residents	Inhalation of chemicals in ground water during in-house use.	Qualitative
Surface Water	Residents (children)	Dermal contact with chemicals in surface water while wading.	Quantitative
Sediment	Residents (children)	Dermal contact with chemicals in sediment while wading.	Quantitative

Based on recent EPA guidance on risk assessment (EPA 1989a), CDIs or SDIs are quantified by estimating the reasonable maximum exposure (RME) associated with the pathway of concern. The RME is intended to represent a possible upper-bound exposure to a typical individual and is combined with upper-bound toxicity criteria to estimate risks. The RME for a given pathway is derived by combining the upper 95% confidence limit of the arithmetic mean exposure point concentration (or the maximum detected value, if lower) for each chemical with reasonable maximum values describing the extent, frequency, and duration of exposure (EPA 1989b). A statistical procedure developed by Land (1971, 1975) was used to calculate the upper 95% confidence interval of the arithmetic mean for chemicals detected in media at the Arrowhead Plating site.

The methodologies used to estimate CDIs or SDIs are presented below by medium. Exposure point concentrations are first presented and then are combined with the other exposure parameters to estimate intake for each exposure pathway.

#### ***7.3.2.1 Worker Inhalation Exposures to Chemicals That Have Volatilized From Surface Soil***

Potential worker exposures via inhalation of chemicals that have volatilized from surface soil are estimated in this section. RME air concentrations for the current worker inhalation exposure pathway were calculated using RME surface soil concentrations. The surface soil concentrations for each area are presented in Table 7-8.

These RME surface soil concentrations were then used to calculate RME concentrations of volatile and semi-volatile organic chemicals in indoor air for the worker exposure scenario by assuming that organic chemicals from the five contaminated soil areas sampled at the site volatilize from the contaminated soil and enter the manufacturing building through the ventilation system, windows, and doors. A complete description of the model used in this assessment is presented in Appendix H. Estimated chemical concentrations in indoor air for the worker scenario are presented in Table 7-9.

Inhalation exposures to chemicals in ambient air are estimated for workers inside the existing manufacturing building. Exposure parameters for the worker population are presented in Table 7-10 and discussed below. Absorption of the inhaled chemical is assumed to be equal to that which occurred in the toxicity studies on which the RfD or cancer potency factor for that chemical is based.

Workers are assumed to breathe at a rate of 2.1 m<sup>3</sup>/hr, which is the inhalation rate reported by EPA (1989b) for males and females engaged in moderate physical activity. Workers are assumed to be exposed to airborne chemicals in the building 8 hours per day, 5 days per week, 50 weeks per year. This corresponds to a typical 40 hour work week with two weeks of vacation and holidays. This results in a total of 250 days of exposure per year. It is assumed that the workers weigh 70 kg and are exposed for 30 years.

Using these assumptions, CDI estimates are calculated using the following equation:

$$CDI = \frac{(C_s)(IR)(ED)(EF)(YE)}{(BW)(DY)(YL)}$$

TABLE 7-8

SURFACE SOIL EXPOSURE POINT CONCENTRATIONS FOR ARROWHEAD PLATING SITE  
(Concentrations reported as mg/kg)

Chemical	Exposure Point Concentration (a)				
	Acid Tank Area	Drain Lines Area	Stained Area	Drum Storage Areas	Solvent Tank Area
<b>Organics:</b>					
Acetone	0.098	--	--	0.027 CL	3.200
Bis(2-ethylhexyl)phthalate	0.2	--	1.200	0.24 CL	--
Carbon tetrachloride	--	--	--	0.004 CL	--
1,2-Dichloroethene (total)	--	--	0.580	--	--
Di-n-butylphthalate	--	--	--	0.340 CL	--
Methyl ethyl ketone	0.016	--	--	0.011 CL	--
Methylene chloride	--	--	--	0.0034 CL	--
Phenanthrene	--	--	--	--	0.140
Tetrachloroethene	--	--	0.150	0.062 CL	3.300
1,1,1-Trichloroethane	--	--	--	0.014 CL	0.020
Trichloroethene	--	--	--	0.013 CL	--
<b>Inorganics:</b>					
Aluminum	14,600	10,700	--	8,100 CL	8,500
Barium	67.5	34.6	--	50 CL	137
Cadmium	--	--	--	--	1
Calcium	1,900	300	--	19,300	4,200
Chromium	19	12.5	--	11 CL	13 CL
Copper	36.8	5.1	--	181	7,800
Cyanide	0.7	--	--	8.7	--
Lead	10.4	8.2	--	9	18.6
Mercury	0.2	0.1	--	--	6.4
Nickel	9.5	5.6	--	5.7 CL	14.6
Potassium	524	400	--	820 CL	310 CL
Silver	--	--	--	0.3 CL	0.5
Sodium	94.5	43.6	--	339	138
Zinc	51.3	14.9	--	61 CL	862

(a) Each concentration listed is the lower value of the upper 95th percent confidence limit (CL) on the arithmetic mean concentration and the maximum detected concentration. Values are maximum detected values, except where noted by "CL".

-- = Not selected as a chemical of potential concern in this area.

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TABLE 7-9  
ESTIMATED INDOOR AIR EXPOSURE POINT  
CONCENTRATIONS FOR WORKERS  
AT THE ARROWHEAD PLATING SITE

(Concentrations in ug/m<sup>3</sup>)

Chemical	Exposure Point Concentration (a)
Acetone	6.32E-01
Bis(2-ethylhexyl)phthalate	4.71E-01
Carbon tetrachloride	1.02E-03
Di-n-butylphthalate	8.69E-02
trans-1,2-Dichloroethene	1.76E-01
Methyl ethyl ketone	6.47E-03
Methylene chloride	8.69E-04
Phenanthrene	2.64E-02
Tetrachloroethene	6.83E-01
1,1,1-Trichloroethane	7.35E-03
Trichloroethene	3.32E-03

(a) Estimated based on surface soil concentrations  
using a soil volatilization model. See  
Appendix A for methodology.

TABLE 7-10

EXPOSURE PARAMETERS USED TO ESTIMATE  
 INHALATION EXPOSURES FOR WORKERS INSIDE  
 THE MANUFACTURING BUILDING  
 AT THE ARROWHEAD PLATING SITE

Parameter	Value
Inhalation Rate	2.1 m <sup>3</sup> /hour (a)
Exposure Duration	8 hours/day (b)
Exposure Frequency	250 days/year (c)
Years of Exposure	30 years (b)
Average Body Weight Over Exposure Period	70 kg (b)

(a) Based on EPA (1989b).

(b) Based on EPA (1989a).

(c) Assumes workers work 5 days/week, 50 weeks/year.

where

CDI = chronic daily intake (mg/kg-day);

$C_a$  = exposure point concentration in air (mg/m<sup>3</sup>) presented previously in Table 7-9;

IR = inhalation rate (m<sup>3</sup>/hr);

ED = exposure duration (hrs/day);

EF = exposure frequency (days/yr);

YE = years of exposure;

BW = average body weight over period of exposure (kg);

DY = days in a year; and

YL = period over which risk is being estimated, i.e., a lifetime (70 yr) for potential carcinogens and the period of exposure for noncarcinogens (30 yr).

Based on the assumptions and procedures outlined above, the estimated inhalation CDIs for workers in the on-site building were calculated and are presented in Table 7-11.

#### 7.3.2.2 Ingestion of Ground Water by Future Residents

The exposure point concentrations for the groundwater ingestion pathway are presented in Table 7-12.

To evaluate residential drinking water exposure, it was assumed that residents between the ages of 1 to 30 years old ingest ground water from the site.<sup>5</sup> Individuals within this age range were used to evaluate exposures instead of evaluating exposures in adults only because assuming the lower average body weight of this age group (48 kg based on EPA 1989b) results in higher estimates of exposure than would be calculated using the average adult body weight (70 kg). Future residents are assumed to drink 1.9 L of water each day (the weighted average water ingestion rate for 1- to 30-year-olds based on EPA 1989b) for 30 years (EPA 1989a). In addition, residents are assumed to live for 70 years (EPA 1989a).

Residential drinking water exposures are calculated using these assumptions and the following equation:

$$CDI = \frac{(C_w)(IR)(EF)(ED)(Z)}{(DY)(BW)(YL)}$$

---

<sup>5</sup>30 yr is the average length of time an individual occupies a residence (EPA 1989a).

TABLE 7-11

EXPOSURE POINT CONCENTRATIONS AND CHRONIC DAILY INTAKES  
FOR ONSITE WORKERS EXPOSED VIA INHALATION  
OF CHEMICALS THAT HAVE VOLATILIZED FROM SOILS  
AT THE ARROWHEAD PLATING SITE (a)

Chemical	Exposure Point Concentration (ug/m3)	Estimated Chronic Daily Intake (CDI) (mg/kg-day)
Chemicals Exhibiting Carcinogenic Effects -----		
Carbon tetrachloride	1.02E-03	7.19E-08
Methylene chloride	8.69E-04	6.12E-08
Tetrachloroethene	6.83E-01	4.81E-05
Trichloroethene	3.32E-03	2.34E-07
Chemicals Exhibiting Noncarcinogenic Effects -----		
Methyl ethyl ketone	6.47E-03	1.06E-06
Methylene chloride	8.69E-04	1.43E-07
1,1,1-Trichloroethane	7.35E-03	1.21E-06

(a) CDIs are presented only for chemicals with inhalation toxicity criteria. Chemicals of concern which are not presented due to lack of toxicity criteria are: acetone, bis(2-ethylhexyl) phthalate, di-n-butylphthalate, trans-1,2-dichloroethene, and phenanthrene.

TABLE 7-12

GROUND WATER EXPOSURE POINT CONCENTRATIONS  
FOR THE ARROWHEAD PLATING SITE

(Concentrations in ug/L)

Chemical	Exposure Point Concentration (a)
<b>Organics:</b>	
-----	
Acetone	782.5
Chloroform	7.5 CL
1,1-Dichloroethane	34 CL
1,1-Dichloroethene	6,225
1,2-Dichloroethene (total)	4,400
Methylene chloride	180
Tetrachloroethene	16,400
1,1,1-Trichloroethane	90,500
Trichloroethene	4,450
<b>Inorganics:</b>	
-----	
Aluminum	54,900
Barium	130 CL
Cadmium	3.7 CL
Calcium	39,000 CL
Chromium	72 CL
Copper	2,900 CL
Cyanide	21 CL
Iron	100,000 CL
Lead	36 CL
Mercury	0.1 CL
Nickel	77 CL
Potassium	9,100 CL
Silver	0.6 CL
Sodium	250,500 CL
Zinc	510 CL

(a) Each concentration listed is the lower of the upper 95th percent confidence limit (CL) on the arithmetic mean and the maximum detected value. Maximum detected values are lower except where noted "CL".

where

CDI = chronic daily intake (mg/kg-day);

$C_w$  = exposure point concentration in ground water ( $\mu\text{g/L}$ ), presented previously in Table 7-12;

IR = ingestion rate (L/day);

EF = exposure frequency (days/yr);

ED = exposure duration (years);

Z = conversion factor (mg/1,000  $\mu\text{g}$ );

DY = days in a year;

BW = body weight over the period of exposure (kg); and

YL = period over which risk is being estimated i.e., a lifetime (70 yr) for potential carcinogens and the period of exposure (30 yr) for noncarcinogens.

Exposure assumptions are summarized in Table 7-13, and CDIs calculated using these exposure assumptions are presented in Table 7-14.

#### 7.3.2.3 Residential Inhalation Exposure to Chemicals That Have Volatilized From Surface Soil

In evaluating the potential inhalation risks to future residents, two models were used to obtain estimates of indoor air concentrations. These models are presented in greater detail in Appendix H. One model assumed that a single-story residence with a concrete slab base is constructed directly over each of the contaminated areas without significantly disturbing the surface soil. In this case the predominant migration pathway into the indoor air was assumed to be passive diffusion through the concrete floor.

The second model assumed that a residence is built on site in a location not directly over any of the contaminated areas, and that chemicals are emitted into the air from each of the contaminated areas and dispersed through the air to the location of the residence. The air concentration inside the residence was conservatively assumed to be equal to that of the outdoor air.

The residential air concentrations calculated using the first model were higher than those calculated using the second model; therefore, the air concentrations in future residences at each contaminated area will be used to conservatively evaluate the potential risks to future residents from inhalation. The air concentrations for each contaminated area are presented in Table 7-15.

Residents are conservatively assumed to spend 24 hr/day at their home, 365 days/yr. They are assumed to breathe at a rate of 18  $\text{m}^3/\text{day}$ , which is the weighted average for 1- to 30-year-olds calculated based on data presented by NCRP (1984) and EPA (1985b). It is further assumed that inhaled chemicals are retained in the lung and absorbed into the bloodstream to the same extent as in the toxicity studies on which the RfD or cancer potency factor is based. An average body weight

TABLE 7-13

EXPOSURE PARAMETERS USED TO ESTIMATE EXPOSURES  
FOR FUTURE RESIDENTS INGESTING GROUND WATER  
AT THE ARROWHEAD PLATING SITE

Parameter	Value
Ingestion Rate	1.9 l/day (a)
Exposure Frequency	365 days/year (b)
Years of Exposure	30 years (b)
Average Body Weight Over Exposure Period	48 kg (c)

- (a) Weighted average based on EPA (1989b). Assumes that children age 1-3 years (up to 10 kg) ingest 1 l/day, and individuals over 10 kg ingest 2 l/day.  
(b) Based on EPA (1989a).  
(c) Based on EPA (1989b). Average for individuals 1-30 years of age.

TABLE 7-14

EXPOSURE POINT CONCENTRATIONS AND CHRONIC DAILY INTAKES  
FOR FUTURE INGESTION OF GROUND WATER AT THE ARROWHEAD PLATING SITE (a)

Chemical	Exposure Point Concentration (ug/l)	Estimated Chronic Daily Intake (CDI) (mg/kg-day)
Chemicals Exhibiting Carcinogenic Effects		
Chloroform	7.5	1.27E-04
1,1-Dichloroethene	6,225.0	1.06E-01
Methylene chloride	180.0	3.05E-03
Tetrachloroethene	16,400.0	2.78E-01
Trichloroethene	4,450.0	7.55E-02
Chemicals Exhibiting Noncarcinogenic Effects		
Acetone	782.5	3.10E-02
Barium	130.0	5.15E-03
Cadmium	3.7	1.46E-04
Chloroform	7.5	2.97E-04
Chromium (total)	72.0	2.85E-03
Copper	2,900.0	1.15E-01
Cyanide	21.0	8.31E-04
1,1-Dichloroethane	34.0	1.35E-03
1,1-Dichloroethene	6,225.0	2.46E-01
1,2-Dichloroethene	4,400.0	1.74E-01
Mercury	0.1	3.96E-06
Methylene chloride	180.0	7.12E-03
Nickel	77.0	3.05E-03
Silver	0.6	2.37E-05
Tetrachloroethene	16,400.0	6.49E-01
1,1,1-Trichloroethane	90,500.0	3.58E+00
Trichloroethene	4,450.0	1.76E-01
Zinc	510.0	2.02E-02

(a) CDIs are presented only for chemicals with oral toxicity criteria.  
Chemicals of concern which are not presented due to lack of toxicity  
criteria are: aluminum, calcium, iron, lead, potassium, and sodium.

TABLE 7-15

ESTIMATED INDOOR AIR CONCENTRATIONS FOR FUTURE RESIDENTS  
AT THE ARROWHEAD PLATING SITE  
(Concentrations in ug/m<sup>3</sup>)

Chemical	Exposure Point Concentration (a)			
	Solvent Tank Area	Stained Area	Acid Tank Area	Drum Storage Areas
Acetone	1.26E-02	--	3.85E-04	1.06E-04
Bis(2-ethylhexyl)phthalate	--	5.12E-09	8.54E-10	1.02E-09
Carbon tetrachloride	--	--	--	3.63E-04
trans-1,2-Dichloroethene	--	1.03E-01	--	--
Di-n-butylphthalate	--	--	--	3.28E-07
Methyl ethyl ketone	--	--	6.28E-05	4.32E-05
Methylene chloride	--	--	--	5.23E-04
Phenanthrene	5.06E-07	--	--	--
Tetrachloroethene	3.29E-01	1.50E-02	--	6.18E-03
1,1,1-Trichloroethane	5.29E-03	--	--	3.71E-03
Trichloroethene	--	--	--	1.42E-03

(a) Estimated based on surface soil concentrations using a volatilization model. See Appendix A for methodology.

-- = Not a chemical of concern in this area.

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TABLE 7-16

EXPOSURE PARAMETERS USED TO ESTIMATE INHALATION  
EXPOSURES FOR FUTURE RESIDENTS  
AT THE ARROWHEAD PLATING SITE

Parameter	Value
Inhalation Rate	18 m <sup>3</sup> /day (a)
Exposure Frequency	365 days/year (b)
Years of Exposure	30 years (b)
Average Body Weight Over Exposure Period	48 kg (c)

(a) Weighted average for individuals 1-30 years of age  
based on NRCP (1984) and EPA (1985b) data.

(b) Based on EPA (1989a).

(c) Based on EPA (1989b).

of 48 kg was calculated based on a weighted average of 1- to 30-year-olds as presented in EPA (1989b). Assuming that the 30-year exposure period occurs from 1 to 30 years (as opposed to 30 to 60 years or some other range) is conservative because the lower average body weight of 1- to 30-year-olds results in higher estimates of exposure than would be calculated using an average body weight (70 kg). The assumptions are summarized in Table 7-16.

Using these assumptions, CDI estimates are calculated using the following equation:

$$CDI = \frac{(C_a)(CF)(IR)(EF)(YE)}{(BW)(DY)(YL)}$$

where

CDI = chronic daily intake (mg/kg-day);

$C_a$  = exposure point concentration in air ( $\mu\text{g}/\text{m}^3$ ), presented previously in Table 7-15;

CF = conversion factor ( $10^{-3} \text{ mg}/\mu\text{g}$ )

IR = inhalation rate ( $\text{m}^3/\text{day}$ );

EF = exposure frequency (days/year);

YE = years of exposure;

BW = average body weight over period of exposure (kg);

DY = days in a year; and

YL = period over which risk is being estimated, i.e., a lifetime (70 yr) for potential carcinogens and the period of exposure for noncarcinogens (30 yr).

Based on the assumptions and procedures outlined above, the estimated inhalation CDIs for future residents were calculated and are presented in Table 7-17 through 7-20 for the four contaminated soil areas.

#### **7.3.2.4 Dermal Contact with Chemicals in Surface Soil by Future Residents**

Future residents may be exposed to chemicals in surface soil by dermal contact while playing outdoors as children, and while doing yard work or gardening as adults. Below, surface soil exposure point concentrations (presented earlier in Table 7-8) are used to estimate residential exposures to chemicals via dermal contact.

To determine the amount of time spent outdoors, climatological data were examined (NOAA 1978). The average number of days with temperatures below 32°F is approximately 86 days/yr. On such days it is considerably less likely that individuals will engage in outdoor activities involving dermal contact with soil since more clothing is worn during colder periods. For the remaining 279 days/yr (40 weeks), it is assumed that individuals over 12 years of age engage in outdoor activities at their

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TABLE 7-17

EXPOSURE POINT CONCENTRATIONS AND CHRONIC DAILY INTAKES FOR  
FUTURE RESIDENTS EXPOSED VIA INHALATION AT THE DRUM STORAGE AREAS (a)

Chemical	Exposure Point Concentration (ug/m3)	Estimated Chronic Daily Intake (CDI) (mg/kg-day)
Chemicals Exhibiting Carcinogenic Effects -----		
Carbon tetrachloride	3.63E-04	5.83E-08
Methylene chloride	5.23E-04	8.41E-08
Tetrachloroethene	6.18E-03	9.93E-07
Trichloroethene	1.42E-03	2.28E-07
Chemicals Exhibiting Noncarcinogenic Effects -----		
Methyl ethyl ketone	4.32E-05	1.62E-08
Methylene chloride	5.23E-04	1.96E-07
1,1,1-Trichloroethane	3.71E-03	1.39E-06

(a) CDIs are presented only for chemicals with inhalation toxicity criteria. Chemicals of concern which are not presented due to lack of toxicity criteria are: acetone, bis(2-ethylhexyl)phthalate, and di-n-butylphthalate.

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TABLE 7-18

EXPOSURE POINT CONCENTRATIONS AND CHRONIC DAILY INTAKES  
FOR FUTURE RESIDENTS EXPOSED VIA INHALATION AT THE ACID TANK AREA (a)

Chemical	Exposure Point Concentration (ug/m3)	Estimated Chronic Daily Intake (CDI) (mg/kg-day)
Chemicals Exhibiting Carcinogenic Effects ----- None		
Chemicals Exhibiting Noncarcinogenic Effects -----		
Methyl ethyl ketone	6.28E-05	2.4E-08

(a) CDIs are presented only for chemicals with inhalation toxicity criteria. Chemicals of concern which are not presented due to lack of toxicity criteria are: acetone and bis(2-ethylhexyl)phthalate.

TABLE 7-19

EXPOSURE POINT CONCENTRATIONS AND CHRONIC DAILY INTAKES  
FOR FUTURE RESIDENTS EXPOSED VIA INHALATION  
AT THE SOLVENT TANK AREA (a)

Chemical	Exposure Point Concentration (ug/m <sup>3</sup> )	Estimated Chronic Daily Intake (CDI) (mg/kg-day)
Chemicals Exhibiting Carcinogenic Effects -----		
Tetrachloroethene	3.29E-01	5.29E-05
Chemicals Exhibiting Noncarcinogenic Effects -----		
1,1,1-Trichloroethane	5.29E-03	1.98E-06

(a) CDIs are presented only for chemicals with inhalation toxicity criteria. Chemicals of concern which are not presented due to lack of toxicity criteria are: acetone and phenanthrene.

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TABLE 7-20

EXPOSURE POINT CONCENTRATIONS AND CHRONIC DAILY INTAKES  
FOR FUTURE RESIDENTS EXPOSED VIA INHALATION AT THE STAINED AREA (a)

Chemical	Exposure Point Concentration (ug/m3)	Estimated Chronic Daily Intake (CDI) (mg/kg-day)
Chemicals Exhibiting Carcinogenic Effects -----		
Tetrachloroethene	1.50E-02	2.41E-06
Chemicals Exhibiting Noncarcinogenic Effects -----		
None		

(a) CDIs are presented only for chemicals with inhalation toxicity criteria. Chemicals of concern which are not presented due to lack of toxicity criteria are: acetone and trans-1,2-dichloroethene.

home 3 days per week, and that children up to 12 years of age play outdoors 5 days per week. A weighted average exposure frequency of 152 days/yr is calculated from this information. The duration of exposure is 30 years, from 1 to 30 years of age (EPA 1989a). An average weight of 48 kg (for individuals 1 to 30 years of age) was assumed (EPA 1989b).

A soil contact rate of 2,320 mg/day was calculated based on the average surface area of 1,600 cm<sup>2</sup> for the hands and forearms of 1- to 30-year-olds (EPA 1989b) and a soil to skin adherence factor of 1.45 mg soil/cm<sup>2</sup> (EPA 1989a) per day in which exposure occurs. Absorption of chemicals through the skin and into the bloodstream varies depending on chemical properties such as solubility and lipophilicity. It is assumed that 10% of VOCs in contacted soil are absorbed through the skin. This value is based on analogy to other chemicals and chemical-physical properties. It is assumed that 3% of bis(2-ethylhexyl) phthalate in contacted soil is absorbed through the skin based on analogy to polychlorinated dibenzo-*p*-dioxins and -furans (PCDDs/PCDFs) (Poiger and Schlatter 1980) (based on studies by Skog and Wahlberg 1964, Wahlberg 1968, and Lang and Kunze 1948). Cyanide, in solution as hydrogen cyanide, is known to be absorbed through the skin. Since no absorption factor is available for cyanide, it is conservatively assumed that all of the cyanide in contacted soil is absorbed. The exposure assumptions are summarized in Table 7-21.

A chronic daily intake is calculated by the following equation:

$$CDI = \frac{(C_s)(CF)(SC)(ABS)(EF)(ED)}{(BW)(DY)(YL)}$$

where

CDI = chronic daily intake (mg/kg-day);

C<sub>s</sub> = chemical concentration in surface soil (mg/kg), presented previously in Table 6-8;

CF = conversion factor (10<sup>-6</sup> kg/mg);

SC = soil contact rate (mg/day);

ABS = absorption factor (percent, unitless);

EF = exposure frequency (days/year);

ED = exposure duration (years);

BW = body weight (kg);

DY = days in a year

YL = period over which risk is being estimated (a lifetime [70 years] for potential carcinogens and the period of exposure for noncarcinogens [30 years]).

TABLE 7-21

EXPOSURE PARAMETERS USED TO ESTIMATE DERMAL CONTACT  
EXPOSURES FOR FUTURE RESIDENTS  
AT THE ARROWHEAD PLATING SITE

Parameter	Value
Soil Contact Rate	2,320 mg/day (a)
Absorption Factor	
VOCs	0.1 (b)
Bis(2-ethylhexyl)phthalate	0.03 (c)
metals	0 (d)
cyanide	1.0 (e)
Exposure Frequency	152 days/year (f)
Years of Exposure	30 years (a)
Average Body Weight Over Exposure Period	48 kg (g)

- (a) Based on hands and forearms surface area of 1,600 cm<sup>2</sup>/day from EPA (1989b), and a soil to skin adherence factor of 1.45 mg/cm<sup>2</sup> (EPA 1989a).
- (b) Assumed value based on analogy to other chemicals and chemical-physical properties.
- (c) Based on analogy to PCDDs/PCDFs (Poiger and Schlatter 1980).
- (d) Based on Skog and Wahlberg 1964, Wahlberg 1968, and Lang and Kunze 1948.
- (e) Cyanide, in solution as hydrogen cyanide, is known to be absorbed through the skin. Since no absorption is available for cyanide, the absorption fraction is conservatively assumed to be 100%.
- (f) Based on NOAA (1978) data collected at Richmond, VA. Assumes that residents spend time outdoors from March through October (279 days, or 40 weeks), and that children up to 12 years of age play outdoors 5 days/week, and individuals over 12 years of age are outdoors 3 days/week.
- (g) Based on EPA (1989b). Average for individuals 1-30 years of age.

TABLE 7-22

EXPOSURE POINT CONCENTRATIONS AND CHRONIC DAILY INTAKES  
FOR DERMAL CONTACT WITH SOIL IN DRUM STORAGE AREAS BY  
FUTURE RESIDENTS AT THE ARROWHEAD PLATING SITE (a)

Chemical	Exposure Point Concentration (mg/kg)	Estimated Chronic Daily Intake (CDI) (mg/kg-day) (b)
Chemicals Exhibiting Carcinogenic Effects		
Bis(2-ethylhexyl)phthalate	0.24	6.21E-08
Carbon tetrachloride	0.004	3.45E-09
Methylene chloride	0.0034	2.93E-09
Tetrachloroethene	0.062	5.35E-08
Trichloroethene	0.013	1.12E-08
Chemicals Exhibiting Noncarcinogenic Effects		
Acetone	0.0270	5.43E-08
Bis(2-ethylhexyl)phthalate	0.24	1.45E-07
Carbon tetrachloride	0.004	8.05E-09
Cyanide	8.7	1.75E-04
Di-n-butylphthalate	0.340	6.84E-07
Methyl ethyl ketone	0.011	2.21E-08
Methylene chloride	0.0034	6.84E-09
Tetrachloroethene	0.062	1.25E-07
1,1,1-Trichloroethane	0.014	2.82E-08
Trichloroethene	0.013	2.62E-08

- (a) CDIs are presented only for chemicals with toxicity criteria. Chemicals of concern which are not presented due to lack of toxicity criteria are: aluminum, calcium, lead, potassium, and sodium.
- (b) No CDIs are presented for inorganic chemicals (except cyanide) because dermal absorption of these chemicals is assumed to be zero.

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TABLE 7-23

EXPOSURE POINT CONCENTRATIONS AND CHRONIC DAILY INTAKES  
FOR DERMAL CONTACT WITH ACID TANK AREA SOIL BY  
FUTURE RESIDENTS AT THE ARROWHEAD PLATING SITE (a)

Chemical	Exposure Point Concentration (mg/kg)	Estimated Chronic Daily Intake (CDI) (mg/kg-day) (b)
Chemicals Exhibiting Carcinogenic Effects -----		
Bis(2-ethylhexyl)phthalate	0.2	5.18E-08
Chemicals Exhibiting Noncarcinogenic Effects -----		
Acetone	0.098	1.97E-07
Bis(2-ethylhexyl)phthalate	0.2	1.21E-07
Cyanide	0.7	1.41E-05
Mercury	0.2	0.00E+00
Methyl ethyl ketone	0.016	3.22E-08

- (a) CDIs are presented only for chemicals with toxicity criteria.  
Chemicals of concern which are not presented due to lack of toxicity  
criteria are: aluminum, calcium, potassium, and sodium.
- (b) No CDIs are presented for inorganic chemicals (except cyanide) because  
dermal absorption of these chemicals is assumed to be zero.

27-Mar-91 -- Arrowhead-DTCETNK

TABLE 7-24

EXPOSURE POINT CONCENTRATIONS AND CHRONIC DAILY INTAKES  
FOR DERMAL CONTACT WITH SOLVENT TANK AREA SOIL BY  
FUTURE RESIDENTS AT THE ARROWHEAD PLATING SITE (a)

Chemical	Exposure Point Concentration (mg/kg)	Estimated Chronic Daily Intake (CDI) (mg/kg-day) (b)
Chemicals Exhibiting Carcinogenic Effects -----		
Tetrachloroethene	3.3	2.85E-06
Chemicals Exhibiting Noncarcinogenic Effects -----		
Acetone	3.2	6.44E-06
Phenanthrene	0.14	2.82E-07
Tetrachloroethene	3.3	6.64E-06
1,1,1-Trichloroethane	0.02	4.03E-08

(a) CDIs are presented only for chemicals with toxicity criteria.  
Chemicals of concern which are not presented due to lack of toxicity

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TABLE 7-25

EXPOSURE POINT CONCENTRATIONS AND CHRONIC DAILY INTAKES  
FOR DERMAL CONTACT WITH STAINED AREA SOIL  
BY FUTURE RESIDENTS AT THE ARROWHEAD PLATING SITE

Chemical	Exposure Point Concentration (mg/kg)	Estimated Chronic Daily Intake (CDI) (mg/kg-day)
Chemicals Exhibiting Carcinogenic Effects -----		
Bis(2-ethylhexyl)phthalate	1.2	3.11E-07
Tetrachloroethene	0.15	1.29E-07
Chemicals Exhibiting Noncarcinogenic Effects -----		
Bis(2-ethylhexyl)phthalate	1.2	7.25E-07
1,2-Dichloroethene	0.58	1.17E-06
Tetrachloroethene	0.15	3.02E-07

Estimated chronic daily intakes are presented in Table 7-22 through 7-25 for four contaminated soil areas: drum storage area, acid tank area, solvent tank area, and stained area.

Chronic daily intakes associated with dermal contact of soil from the drain lines area are not presented because only inorganic chemicals were detected, and it is assumed that inorganic chemicals are not absorbed through the skin (absorption factor = 0) (Skog and Wahlberg 1964; Wahlberg 1968a,b; Lang and Kunze 1948).

#### 7.3.2.5 Incidental Ingestion of Chemicals in Surface Soil by Future Residents

Future residents also may be exposed to chemicals in surface soil by incidental ingestion. The surface soil exposure point concentrations for incidental ingestion by future residents are those presented in Table 7-8. Exposure frequency (152 days), exposure duration (30 years), and body weight (48 kg) are the same as for the dermal contact pathway above. Individuals are assumed to ingest 120 mg of soil per day. This value is the weighted average of the soil ingestion rate for children ages 1 to 6 years (200 mg/kg) and the soil ingestion rate for individuals 7 to 30 years of age (100 mg/kg) reported by EPA (1989a). All of the ingested soil is assumed to be contaminated. Relative oral bioavailability factors were also applied to take into account the reduced bioavailability of the chemicals of concern from a soil matrix. Factors for the inorganic chemicals (except cyanide) were based on a study by Fraser and Lum (1983). Factors for mercury and silver are based on analogy to those for inorganics most likely to behave similarly (i.e., mercury = cadmium and silver = copper). A factor of 0.2 for cyanide was derived by Clement International Corporation (1990). A relative oral bioavailability factor of 0.5 was estimated for bis(2-ethylhexyl) phthalate based on analogy to 2,3,7,8-TCDD, a chemical which has been extensively studied by Poiger and Schlatter (1980), McConnell et al. (1989), Lucier et al. (1986), Wendling et al. (1989), and van den Berg et al. (1986, 1987). Since no relative oral bioavailability factors were available for the other organic chemicals of potential concern, it was conservatively assumed that all of these other organic chemicals in ingested soil are 100% bioavailable. These exposure assumptions are summarized in Table 7-26. Using these assumptions, CDI estimates for incidental ingestion of chemicals in surface soil were calculated using the equation below:

$$CDI = \frac{(C_s)(IR)(CF)(BA)(EF)(ED)}{(BW)(DY)(YL)}$$

where

CDI = chronic daily intake (mg/kg-day);

$C_s$  = chemical concentration in surface soil (mg/kg), presented previously in Table 7-8;

BA = relative oral bioavailability factor (fraction; unitless);

IR = ingestion rate (mg soil/day);

CF = conversion factor (1 kg/10<sup>6</sup> mg)

EF = exposure frequency (days/year);

TABLE 7-26

EXPOSURE PARAMETERS USED TO ESTIMATE SOIL INGESTION  
EXPOSURES FOR FUTURE RESIDENTS  
AT THE ARROWHEAD PLATING SITE

Parameter	Value
Ingestion Rate	120 mg/day (a)
Fraction of Ingested Soil Which is from Contaminated Areas	1 (a)
Relative Oral Bioavailability (b)	
Inorganic Chemicals:	
Barium	0.29
Cadmium	0.11
Chromium	0.003
Copper	0.11
Cyanide	0.2 (c)
Mercury	0.11 (d)
Nickel	0.048
Silver	0.11 (e)
Zinc	0.1
Organic Chemicals:	
Bis(2-ethylhexyl)phthalate	0.5 (f)
All others	1.0 (g)
Frequency	152 days/year (h)
Years of Exposure	30 years (a)
Average Body Weight Over Exposure Period	48 kg (i)

(a) Based on EPA (1989a).

(b) From Fraser and Lum (1983) except where noted.

(c) From Clement International Corporation (1990).

(d) Based on cadmium.

(e) Based on copper.

(f) Estimated based on 2,3,7,8-TCDD (Poiger and Schlatter 1980, McConnel et al. 1984, Lucier et al. 1986, Wendling et al. 1989, and van den Berg et al. 1986, 1987).

(g) Assumed value.

(h) Based on NOAA (1978) data collected at Richmond, VA. Assumes that residents spend time outdoors from March through October (279 days, or 40 weeks), and that children up to 12 years of age play outdoors 5 days/week, and individuals over 12 years of age are outdoors 3 days/week.

(i) Based on EPA (1989b). Average for individuals 1-30 years of age.

ED = exposure duration (years);

BW = average body weight over period of exposure (kg);

DY = days in a year; and

YL = period over which risk is being estimated, i.e., a lifetime (70 yr) for potential carcinogens and the period of exposure for noncarcinogens (30 yr).

Chronic daily intakes for the soil ingestion pathway are presented in Tables 7-27 through 7-31 for the five contaminated soil areas.

#### ***7.3.2.6 Dermal Contact with Chemicals in Surface Water by Wading Children***

The surface water exposure point concentrations were estimated using all surface water samples, assuming that there would be an equal probability of children playing at any location which was sampled. The concentrations used to assess future surface water exposures are presented in Table 7-32.

Children between the ages of 6 and 12 years are assumed to weight 31 kg (based on EPA 1989b) and to play in Scates Branch and the millpond for a total of 6 years. It is unlikely that children will wade in streams during the winter months. Therefore, an annual exposure duration was calculated based on the number of days that the average daily temperature is over 65°F. Based on data from NOAA (1978), the average daily temperature exceeds 65°F for the 6 month period from April through September, or approximately 180 days (25.7 weeks). During these months it was assumed that children between the ages of 6 and 12 years of age wade in Scates Branch 3 days/week. Since children are likely to play outdoors after school as well as on weekends or during summer months, no differentiation was made for the months that children are attending school. This exposure frequency results in a total of 77 days of exposure each year (3 days/week \* 25.7 weeks/year). Children are assumed to be exposed for 2 hours on the days they wade in Scates Branch and the millpond. In estimating exposure via dermal contact with chemicals in surface water, the area of exposed skin is assumed to be 3,600 cm<sup>2</sup>, which is the average area of the feet and legs of 6 to 12 year-old children (calculated from data in EPA 1989b). Chemical-specific permeability constants could not be identified for the chemicals of potential concern in Scates Branch surface water. Therefore, organic chemicals and cyanide are assumed to penetrate the skin at the rate of water penetration as recommended by EPA (1989a). EPA (1989a) reports a permeability constant of  $8 \times 10^{-4}$  cm/hr for water based on data reported by Blank et al. (1984). Dermal absorption of metals is assumed to be negligible given the relatively low permeability of the skin to metal ions. Therefore, dermal exposure to inorganic chemicals was not evaluated in this assessment. Children are assumed to weigh 31 kg, which is the average body weight for 6 to 12 year-old children (calculated from data in EPA 1989b). These exposure assumptions are summarized in Table 7-32.

Using these assumptions, SDI estimates for dermal absorption of chemicals in surface water were calculated using the equation below:

27-Mar-91 -- Arrowhead-DRUM

TABLE 7-27

EXPOSURE POINT CONCENTRATIONS AND CHRONIC DAILY INTAKES  
FOR INCIDENTAL INGESTION OF SOIL IN DRUM STORAGE AREAS  
BY FUTURE RESIDENTS AT THE ARROWHEAD PLATING SITE (a)

Chemical	Exposure Point Concentration (mg/kg)	Estimated Chronic Daily Intake (CDI) (mg/kg-day)
Chemicals Exhibiting Carcinogenic Effects -----		
Bis(2-ethylhexyl)phthalate	0.24	5.35E-08
Carbon tetrachloride	0.004	1.78E-09
Methylene chloride	0.0034	1.52E-09
Tetrachloroethene	0.062	2.77E-08
Trichloroethene	0.013	5.80E-09
Chemicals Exhibiting Noncarcinogenic Effects -----		
Acetone	0.0270	2.81E-08
Barium	50.0	1.51E-05
Bis(2-ethylhexyl)phthalate	0.24	1.25E-07
Carbon tetrachloride	0.004	4.16E-09
Chromium	11	3.44E-08
Copper	181.0	2.07E-05
Cyanide	8.7	1.81E-06
Di-n-butylphthalate	0.340	3.54E-07
Methyl ethyl ketone	0.011	1.15E-08
Methylene chloride	0.0034	3.54E-09
Nickel	5.7	2.85E-07
Silver	0.3	3.44E-08
Tetrachloroethene	0.062	6.45E-08
1,1,1-Trichloroethane	0.014	1.46E-08
Trichloroethene	0.013	1.35E-08
Zinc	61.0	6.35E-06

(a) CDIs are presented only for chemicals with oral toxicity criteria.  
Chemicals of concern which are not presented due to lack of toxicity

27-Mar-91 -- Arrowhead-ACIDTNK

TABLE 7-28

EXPOSURE POINT CONCENTRATIONS AND CHRONIC DAILY INTAKES FOR INCIDENTAL  
INGESTION OF ACID TANK AREA SOIL BY FUTURE RESIDENTS  
AT THE ARROWHEAD PLATING SITE (a)

Chemical	Exposure Point Concentration (mg/kg)	Estimated Chronic Daily Intake (CDI) (mg/kg-day)
Chemicals Exhibiting Carcinogenic Effects -----		
Bis(2-ethylhexyl)phthalate	0.2	4.46E-08
Chemicals Exhibiting Noncarcinogenic Effects -----		
Acetone	0.098	1.02E-07
Barium	67.5	2.04E-05
Bis(2-ethylhexyl)phthalate	0.2	1.04E-07
Chromium	19	5.93E-08
Copper	36.8	4.21E-06
Cyanide	0.7	1.46E-07
Mercury	0.2	2.29E-08
Methyl ethyl ketone	0.016	1.67E-08
Nickel	9.5	4.75E-07
Zinc	51.3	5.34E-06

(a) CDIs are presented only for chemicals with oral toxicity criteria.  
Chemicals of concern which are not presented due to lack of toxicity  
criteria are: aluminum, calcium, lead, potassium, and sodium.

TABLE 7-29

EXPOSURE POINT CONCENTRATIONS AND CHRONIC DAILY INTAKES  
FOR INCIDENTAL INGESTION OF SOLVENT TANK AREA SOIL  
BY FUTURE RESIDENTS AT THE ARROWHEAD PLATING SITE (a)

Chemical	Exposure Point Concentration (mg/kg)	Estimated Chronic Daily Intake (CDI) (mg/kg-day)
Chemicals Exhibiting Carcinogenic Effects -----		
Tetrachloroethene	3.3	1.47E-06
Chemicals Exhibiting Noncarcinogenic Effects -----		
Acetone	3.2	3.33E-06
Barium	137.0	4.14E-05
Cadmium	1.0	1.15E-07
Chromium	13	4.06E-08
Copper	7800	8.93E-04
Mercury	6.4	7.33E-07
Nickel	14.6	7.30E-07
Phenanthrene	0.14	1.46E-07
Silver	0.5	5.73E-08
Tetrachloroethene	3.3	3.44E-06
1,1,1-Trichloroethane	0.02	2.08E-08
Zinc	862	8.97E-05

(a) CDIs are presented only for chemicals with oral toxicity criteria.  
Chemicals of concern which are not presented due to lack of  
toxicity criteria are: aluminum, calcium, lead, potassium,  
and sodium.

27-Mar-91 -- Arrowhead-DRAINLNE

TABLE 7-30

EXPOSURE POINT CONCENTRATIONS AND CHRONIC DAILY INTAKES  
FOR INCIDENTAL INGESTION OF DRAIN LINES AREA SOIL  
BY FUTURE RESIDENTS AT THE ARROWHEAD PLATING SITE (a)

Chemical	Exposure Point Concentration (mg/kg)	Estimated Chronic Daily Intake (CDI) (mg/kg-day)
Chemicals Exhibiting Carcinogenic Effects -----		
None		
Chemicals Exhibiting Noncarcinogenic Effects -----		
Barium	34.6	1.04E-05
Chromium	12.5	3.90E-08
Copper	5.1	5.84E-07
Mercury	0.1	1.15E-08
Nickel	5.6	2.80E-07
Zinc	14.9	1.55E-06

(a) CDIs are presented only for chemicals with oral toxicity criteria.  
Chemicals of concern which are not presented due to lack of  
toxicity criteria are: aluminum, calcium, lead, potassium,

27-Mar-91 -- Arrowhead-STAINED

TABLE 7-31

EXPOSURE POINT CONCENTRATIONS AND CHRONIC DAILY INTAKES  
FOR INCIDENTAL INGESTION OF STAINED AREA SOIL  
BY FUTURE RESIDENTS AT THE ARROWHEAD PLATING SITE

Chemical	Exposure Point Concentration (mg/kg)	Estimated Chronic Daily Intake (CDI) (mg/kg-day)
Chemicals Exhibiting Carcinogenic Effects		
Bis(2-ethylhexyl)phthalate	1.2	2.68E-07
Tetrachloroethene	0.15	6.69E-08
Chemicals Exhibiting Noncarcinogenic Effects		
Bis(2-ethylhexyl)phthalate	1.2	6.25E-07
1,2-Dichloroethene	0.58	6.04E-07
Tetrachloroethene	0.15	1.56E-07

TABLE 7-32  
SURFACE WATER EXPOSURE POINT CONCENTRATIONS  
FOR THE ARROWHEAD PLATING SITE  
(Concentrations in ug/L)

Chemical	Exposure Point Concentration (a)
Organics:	
-----	
Bis(2-ethylhexyl)phthalate	9.5 CL
1,2-Dichloroethene (total)	25
Tetrachloroethene	37.8
Trichloroethene	34
Inorganics:	
-----	
Aluminum	2,395
Calcium	19,625
Copper	10.8
Cyanide	12 CL
Iron	5,100 CL
Potassium	7,700 CL
Sodium	106,800

(a) Each concentration listed is the lower of the upper 95th percent confidence limit (CL) on the arithmetic mean and the maximum detected value. Maximum detected values are lower except where noted "CL".

TABLE 7-33

EXPOSURE PARAMETERS USED TO ESTIMATE DERMAL CONTACT  
EXPOSURES FOR CHILDREN WADING IN SURFACE WATER  
AT THE ARROWHEAD PLATING SITE

Parameter	Value
Surface Area Exposed	3,600 cm <sup>2</sup> (a)
Dermal Permeability	
Organic Chemicals	0.0008 cm/hr (b)
Inorganic Chemicals	0 cm/hr (c)
Exposure Duration	2 hours/day
Exposure Frequency	77 days/year (d)
Years of Exposure	6 years (e)
Average Body Weight Over Exposure Period	31 kg (f)

- (a) Based on EPA (1989b). Surface area of feet and legs for 6-12 year old children.
- (b) Based on EPA (1989a). Assumes that all organic chemicals penetrate skin at same rate as water.
- (c) Dermal permeability of inorganic chemicals is assumed to be negligible.
- (d) Assumes that children 6-12 years waded in water 3 days/week during months when average daily temperature is over 65°F (6 months: April - September).
- (e) Assumes children waded in stream from age 6 to age 12.
- (f) Based on EPA (1989a). Average body weight for children 6-12 years old.

$$SDI = \frac{(C_w)(PC)(SA)(ET)(EF)(ED)(Z)(Y)}{(BW)(DY)(YL)}$$

where

SDI = subchronic daily intake (mg/kg-day);

$C_w$  = chemical concentration in water ( $\mu\text{g/L}$ ), presented previously in Table 6-32;

PC = dermal permeability constant (cm/hr);

SA = skin surface area exposed ( $\text{cm}^2$ );

ET = exposure time (hr/day);

EF = exposure frequency (days/year);

ED = exposure duration (years);

Y = conversion factor (1 mg/1,000  $\mu\text{g}$ );

Z = conversion factor (1 L/1,000  $\text{cm}^3$ );

BW = average body weight over period of exposure (kg);

DY = days in a year; and

YL = period over which risk is being estimated, i.e., a lifetime (70 years) for potential carcinogens and the period of exposure for noncarcinogens (6 years).

These intake estimates are presented in Table 7-34.

#### 7.3.2.7 Dermal Contact with Chemicals in Sediment by Wading Children

Sediment exposure point concentrations were calculated using the same methodology as described for surface water. These concentrations are presented in Table 7-35.

The exposure frequency, duration, and average body weight discussed above for dermal contact with surface water were used to estimate exposure to chemicals in sediment as well. However, it is unlikely that the entire surface area of feet and legs will contact sediment. Therefore, the surface area for feet only was calculated to be  $714 \text{ cm}^2$  (EPA 1989b). Using a skin adherence factor of  $1.45 \text{ mg/cm}^2$  per day in which exposure occurs (the same as was used for contact with surface soil), a sediment contact rate of  $1,035 \text{ mg/day}$  was calculated. Dermal permeability of chemicals in sediments was assumed to equal that of the same chemicals in soils. Exposure parameters used in this pathway are summarized in Table 7-36. A subchronic daily intake is calculated by the following equation:

TABLE 7-34

EXPOSURE POINT CONCENTRATIONS AND CHRONIC DAILY INTAKES DUE  
TO DERMAL CONTACT WITH SURFACE WATER BY WADING  
CHILDREN AT THE ARROWHEAD SITE

Chemical	Exposure Point Concentration (ug/l)	Chronic Daily Intake (CDI) (mg/kg-day)
Chemicals Exhibiting Carcinogenic Effects		
Bis(2-ethylhexyl)phthalate	9.5	3.19E-08
Tetrachloroethene	37.8	1.27E-07
Trichloroethene	34.0	1.14E-07
Chemicals Exhibiting Noncarcinogenic Effects		
Bis(2-ethylhexyl)phthalate	9.5	3.72E-07
Cyanide	12.0	4.70E-07
1,2-Dichloroethene (total)	25.0	9.80E-07
Tetrachloroethene	37.8	1.48E-06

TABLE 7-35

SEDIMENT EXPOSURE POINT CONCENTRATIONS  
FOR THE ARROWHEAD PLATING SITE

(Concentrations in mg/kg)

Chemical	Exposure Point Concentration (a)
Organics:	
Acetone	0.068
Benzoic acid	0.73
Bis(2-ethylhexyl)phthalate	0.35 CL
1,2-Dichloroethene (total)	0.0042 CL
Methyl ethyl ketone	0.011 CL
Tetrachloroethene	0.008 CL
Trichloroethene	0.0044 CL
Inorganics:	
Calcium	675
Nickel	9.2
Sodium	151

(a) Each concentration listed is the lower of the upper 95th percent confidence limit (CL) on the arithmetic mean and the maximum detected value. Maximum detected values are lower except where noted "CL".

TABLE 7-36

EXPOSURE PARAMETERS USED TO ESTIMATE DERMAL CONTACT  
EXPOSURES FOR CHILDREN CONTACTING SEDIMENT  
AT THE ARROWHEAD PLATING SITE

Parameter	Value
Sediment Contact Rate	1,035 mg/cm <sup>2</sup> (a)
Dermal Permeability	
Organic chemicals	0.1 (b)
Metals	0
Bis(2-ethylhexyl)phthalate	0.03
Exposure Frequency	77 days/year (c)
Years of Exposure	6 years (d)
Average Body Weight Over Exposure Period	31 kg (e)

- (a) Based on feet surface area of 714 cm<sup>2</sup> from EPA 1989b and an assumed sediment to skin adherence factor of 1.45 mg/cm<sup>2</sup> (the same as soil, from EPA 1989a).  
 (b) Dermal permeability of chemicals in sediment is assumed to equal that of the same chemicals in soils. See Table 6-21 for basis of values.  
 (c) Assumes that children 6-12 years wade in water 3 days/week during months when average daily temperature is over 65°F (6 months: April - September).  
 (d) Assumes children wade in stream from age 6 to age 12.  
 (e) Based on EPA (1989a). Average body weight for children 6-12 years old.

$$SDI = \frac{(C_{sd})(CF)(SC)(ABS)(EF)(ED)}{(BW)(DY)(YL)}$$

where

SDI = subchronic daily intake (mg/kg-day);

$C_{sd}$  = chemical concentration in sediment (mg/kg), presented previously in Table 6-35;

CF = conversion factor ( $10^{-6}$  kg/mg);

SC = sediment contact rate (mg/day);

ABS = absorption factor (percent, unitless);

EF = exposure frequency (days/year);

ED = exposure duration (years);

BW = body weight (kg);

DY = days in a year; and

YL = period over which risk is being estimated (a lifetime [70 years] for potential carcinogens and the period of exposure for noncarcinogens [6 years]).

The SDIs calculated for this pathway are presented in Table 7-37.

## 7.4 TOXICITY ASSESSMENT

The general methodology for the classification of health effects and the development of health effects criteria is described in Section 7.4.1 to provide the analytical framework for the characterization of human health impacts. In Section 7.4.2, the health effects criteria that will be used to derive estimates of risk are presented and the toxicity of the chemicals of potential concern is briefly discussed.

### 7.4.1 Health Effects Classification and Criteria Development

For risk assessment purposes, individual chemicals are separated into two categories of chemical toxicity depending on whether they exhibit noncarcinogenic or carcinogenic effects. This distinction relates to the currently held scientific opinion that the mechanism of action for each category is different. For the purpose of assessing risks associated with potential carcinogens, EPA has adopted the scientific position that a small number of molecular events can cause changes in a single cell or a small number of cells that can lead to tumor formation. This is described as a no-threshold mechanism, because there is essentially no level of exposure (i.e., a threshold) to a carcinogen which will not result in some finite possibility of causing the disease. In the case of chemicals exhibiting noncarcinogenic effects however, it is believed that organisms have protective

Parameters and strings found at V95

TABLE 7-37

EXPOSURE POINT CONCENTRATIONS AND SUBCHRONIC DAILY INTAKES DUE  
TO DERMAL CONTACT WITH SEDIMENT BY WADING  
CHILDREN AT THE ARROWHEAD PLATING SITE (a)

Chemical	Exposure Point Concentration (mg/kg)	Estimated Subchronic Daily Intake (SDI) (mg/kg-day) (b)
Chemicals Exhibiting Carcinogenic Effects -----		
Bis(2-ethylhexyl)phthalate	0.35	6.34E-09
Tetrachloroethene	0.008	4.83E-10
Trichloroethene	0.0044	2.66E-10
Chemicals Exhibiting Noncarcinogenic Effects -----		
Acetone	0.068	4.79E-08
Benzoic acid	0.73	5.14E-07
Bis(2-ethylhexyl)phthalate	0.35	7.40E-08
1,2-Dichloroethene	0.0042	2.96E-09
Methyl ethyl ketone	0.011	7.75E-09
Tetrachloroethene	0.008	5.64E-09

(a) CDIs are presented only for chemicals with toxicity criteria. Chemicals of concern which are not presented due to lack of toxicity criteria are: calcium and sodium.

mechanisms that must be overcome before the toxic endpoint is manifested. For example, if a large number of cells perform the same or similar functions, it would be necessary for significant damage or depletion of these cells to occur before an effect could be seen. This threshold view holds that a range of exposures from just above zero to some finite value can be tolerated by the organism without appreciable risk of causing the disease.

#### **7.4.1.1 Health Effects Criteria for Potential Carcinogens**

Slope factors are developed by EPA's Health Assessment Group (HAG) for potentially carcinogenic chemicals and are expressed in units of  $(\text{mg/kg-day})^{-1}$ . Slope factors are derived from the results of human epidemiological studies or chronic animal bioassays. The animal studies usually must be conducted using relatively high doses to detect possible adverse effects. Because humans are expected to be exposed to doses lower than those used in the animal studies, the data are adjusted by using mathematical models. The data from animal studies are typically fitted to the linearized multistage model to obtain a dose-response curve. The 95th percentile upper confidence limit slope of the dose-response curve is subjected to various adjustments and an interspecies scaling factor is applied to derive the slope factor for humans. Thus, the actual risks associated with exposure to a potential carcinogen quantitatively evaluated based on animal data are not likely to exceed the risks estimated using these slope factors, but they may be much lower. Dose-response data derived from human epidemiological studies are fitted to dose-time-response curves on a case-by-case basis. These models provide rough, but plausible, estimates of the upper limits on lifetime risk. Slope factors based on human epidemiological data are also derived using very conservative assumptions and, as such, they too are unlikely to underestimate risks. Therefore, while the actual risks associated with exposures to potential carcinogens are unlikely to be higher than the risks calculated using a slope factor, they could be considerably lower.

EPA assigns weight-of-evidence classifications to potential carcinogens. Under this system, chemicals are classified as either Group A, Group B1, Group B2, Group C, Group D, or Group E. Group A chemicals (human carcinogens) are agents for which there is sufficient evidence to support the causal association between exposure to the agents in humans and cancer. Groups B1 and B2 chemicals (probable human carcinogens) are agents for which there is limited (B1) or inadequate (B2) evidence of carcinogenicity from human studies but for which there is sufficient evidence of carcinogenicity from animal studies. Group C chemicals (possible human carcinogens) are agents for which there is limited evidence of carcinogenicity in animals, and Group D chemicals (not classified as to human carcinogenicity) are agents with inadequate human and animal evidence of carcinogenicity or for which no data are available. Group E chemicals (evidence of non-carcinogenicity in humans) are agents for which there is no evidence of carcinogenicity in adequate human or animal studies.

#### **7.4.1.2 Health Effects Criteria for Noncarcinogens**

Health criteria for chemicals exhibiting noncarcinogenic effects are generally developed using reference doses (RfDs) developed by the EPA RfD Work Group or RfDs obtained from EPA Health Effects Assessments (HEAs). RfDs are usually derived either from human studies involving work-place exposures or from animal studies and are adjusted using uncertainty factors. The RfD is an estimate of the daily exposure to the human population (including sensitive subpopulations) that is likely to be without an appreciable risk of deleterious effects during a lifetime. The RfD provides a benchmark to which chemical intakes may be compared. EPA has developed chronic and subchronic RfDs, both expressed in units of  $\text{mg/kg-day}$ . Chronic RfDs are specifically developed to

be protective for long-term exposure to a compound; subchronic RfDs are protective for shorter-term exposures. EPA (1989a) recommends that chronic RfDs be used to evaluate exposures of 7 years to a lifetime in duration and subchronic RfDs be used to evaluate exposures of 2 weeks to 7 years in duration. Chronic RfDs will be used in this assessment to evaluate potential noncarcinogenic effects associated with groundwater ingestion, incidental soil ingestion, and inhalation exposures. Subchronic RfDs will be used to evaluate potential noncarcinogenic effects associated with direct contact exposures to chemicals in the surface water and sediment.

#### 7.4.2 Health Effects Criteria for the Chemicals of Potential Concern

Tables 7-38 and 7-39 present chronic health effects criteria for oral and inhalation exposures, respectively. Table 7-40 presents subchronic oral RfDs for some of the chemicals of potential concern in surface water and sediment for which subchronic exposures are being evaluated. Subchronic RfDs have not been developed for every chemical of concern in these media. In the absence of a subchronic RfD, potential noncarcinogenic health effects will be evaluated using the chronic oral RfD.

No oral toxicity criteria are available for aluminum, calcium, iron, lead, potassium, and sodium. However, calcium, iron, potassium, and sodium are essential human nutrients and are toxic only at very high doses. Because of their low toxicity, it is unlikely that contact with these chemicals at the site would result in adverse health effects. There are no toxicity criteria available for lead. Potential risks associated with lead exposures will be evaluated separately in the risk characterization section. No inhalation toxicity criteria are available for 1,2-dichloroethene, acetone, bis(2-ethylhexyl) phthalate, di-*n*-butyl phthalate, and phenanthrene. Therefore, potential risks associated with exposure to these chemicals via inhalation will not be quantitatively evaluated. A qualitative discussion of potential risks associated with these chemicals will be included in the risk characterization section. Toxicity summaries for these chemicals are included in the following sections.

The toxicological properties of the chemicals of potential concern and the toxicological basis of the health effects criteria presented in Tables 7-38 through 7-40 are discussed in Appendix I.

### 7.5 RISK CHARACTERIZATION

In this section, the human health risks potentially associated with the Arrowhead Plating site are evaluated. Risks will be evaluated either quantitatively or qualitatively. To quantitatively assess risks, the CDIs and SDIs calculated in Section 7.3.2.2 are combined with the health effects criteria presented in Section 7.4.2.

For potential carcinogens, excess lifetime cancer risks are obtained by multiplying the CDI for each chemical by its cancer slope factor. A risk level of  $10^{-6}$  represents a probability of one in 1,000,000 that an individual could contract cancer due to exposure to the potential carcinogen. The upper-bound lifetime excess cancer risks derived in this report can be compared to EPA's risk range for health protectiveness at Superfund sites. EPA recommends that the total cancer risk to individuals resulting from exposure at a Superfund site be reduced to zero where possible. EPA has implemented actions under Superfund associated with total cancer risks ranging from  $10^{-4}$  to  $10^{-6}$ .

Potential risks for noncarcinogens are presented as the ratio of the CDI to the reference dose (CDI:RfD) for each chemical. The sum of the ratios of all chemicals under consideration is called

TABLE 7-38

## CHRONIC ORAL TOXICITY VALUES FOR CHEMICALS OF POTENTIAL CONCERN

Chemical	Chronic Reference Dose (mg/kg-day) [Uncertainty Factor] (a)	Target Organ (b)	Reference Dose Source	Cancer Slope Factor (mg/kg-day) <sup>-1</sup>	USEPA Weight of Evidence Classification (c)	Slope Factor Source
<b>Organics</b>						
Acetone	1E-01 [1000]	Liver, kidney	IRIS	--	D	--
Benzoic acid	4E+00 [1]	Irritation	IRIS	--	D	IRIS
Bis(2-ethylhexyl)phthalate	2E-02 [1000]	Liver	IRIS	1.4E-02	B2	IRIS
Carbon tetrachloride	7E-04 [1000]	Liver	IRIS	1.3E-01	B2	IRIS
Chloroform	1E-02 [1000]	Liver	IRIS	6.1E-03	B2	IRIS
1,1-Dichloroethane	1E-01 [1000]	Kidney	HEAST	(d)	C	HEAST
1,1-Dichloroethene	9E-03 [1000]	Liver	IRIS	6E-01	C	IRIS
1,2-Dichloroethene (total)	2E-02 [1000]	Blood serum	IRIS	--	D	--
Di-n-butylphthalate	1E-01 [1000]	Mortality	IRIS	--	D	IRIS
Methylene chloride	6E-02 [100]	Liver	IRIS	7.5E-03	B2	IRIS
Methyl ethyl ketone	5E-02 [1000] (f)	Fetus	IRIS	--	D	IRIS
Phenanthrene (e)	4E-03 [10000]	Eye	IRIS	--	D	IRIS
Tetrachloroethene	1E-02 [1000]	Liver	IRIS	5.1E-02 (g)	B2	HEAST
1,1,1-Trichloroethane	9E-02 [1000]	Liver	IRIS	--	D	IRIS
Trichloroethene	7.35E-03 [1000]	Liver	HA	1.1E-02	B2	HEAST
<b>Inorganics</b>						
Aluminum	--	--	--	--	D	--
Barium	7E-02 [3]	Blood pressure	IRIS	--	D	--
Cadmium (food)	1E-03 [10]	Kidney	IRIS	--	B1	IRIS
(water)	5E-04 [10]	Kidney	IRIS	--	B1	IRIS
Calcium	--	--	--	--	D	--
Chromium (h)	5E-03 [500]	Nervous system	IRIS	--	D	--
Copper	3.7E-02 (i)	GI	HEAST	--	D	IRIS
Cyanide	2E-02 [500]	Thyroid	IRIS	--	D	IRIS
Iron	--	--	--	--	D	--
Lead	--	--	--	--	B2	IRIS
Mercury (inorganic)	3E-04 [1000]	Kidney	HEAST	--	D	IRIS
Nickel	2E-02 [300]	Body weight	IRIS	--	D	--
Potassium	--	--	--	--	D	--
Silver	3E-03 [2]	Argyria (skin)	IRIS	--	D	IRIS
Sodium	--	--	--	--	D	--
Zinc	2E-01 [10]	Anemia	HEAST	--	D	--

(a) Uncertainty factors used to develop reference doses generally consist of multiples of 10, with each factor representing a specific area of uncertainty in the data available. The standard uncertainty factors include the following:

- A 10-fold factor to account for the variation in sensitivity among the members of the human population;
- A 10-fold factor to account for the uncertainty in extrapolation animal data to the case of humans;
- A 10-fold factor to account for uncertainty in extrapolating from less than chronic NOAELs to chronic NOAELs; and
- A 10-fold factor to account for the uncertainty in extrapolating from LOAELs to NOAELs.

(b) A target organ is the organ most sensitive to a chemical's toxic effect. RfD's are based on toxic effects in the target organ. If an RfD was based on a study in which a target organ was not identified, an organ or system known to be affected by the chemical is listed.

(c) EPA Weight of Evidence for Carcinogenic Effects: [A] = Human carcinogen based on adequate evidence from human studies; [B2] = Probable human carcinogen based on inadequate evidence from human studies and adequate evidence from animal studies; [C] = Possible human carcinogen based on limited evidence from animal studies in the absence of human studies; [D] = Not classified as to human carcinogenicity; and [E] = Evidence of noncarcinogenicity.

(d) Withdrawn by EPA.

(e) Toxicity criteria for naphthalene are used in the absence of criteria for phenanthrene.

(f) Based on route to route extrapolation. Being reconsidered by the RfD workgroup.

(g) Under review by CRAVE workgroup.

(h) Toxicity criteria reported is for chromium VI, as all chromium is conservatively assumed to be in the form of chromium VI.

(i) Drinking water standard reported in mg/l is converted to mg/kg-day by assuming a 70 kg adult consumes 2 liters of water per day.

NOTE: IRIS = Integrated Risk Information System - October 1, 1990  
 HEAST = Health Effects Assessment Summary Tables - July 1, 1990  
 HA = Drinking Water Health Advisory  
 EPA = Environmental Protection Agency  
 -- = No information available

TABLE 7-39

## CHRONIC INHALATION TOXICITY VALUES FOR CHEMICALS OF POTENTIAL CONCERN

Chemical	Chronic Reference Dose (mg/kg-day) [Uncertainty Factor] (a)	Reference Dose Source	Target Organ (b)	Cancer Slope Factor (mg/kg-day) <sup>-1</sup>	USEPA Weight of Evidence Classification (c)	Slope Factor Source
<b>Organics</b>						
Acetone	--	--	--	--	D	--
Bis(2-ethylhexyl)phthalate	--	--	--	--	B2	IRIS
Carbon tetrachloride	--	--	--	1.3E-01	B2	IRIS
1,2-Dichloroethene	--	--	--	--	D	--
Di-n-butylphthalate	--	--	--	--	D	--
Methylene chloride	8.57E-01 [100] (d)	HEAST	Liver	1.6E-03 (e)	B2	IRIS
Methyl ethyl ketone	9E-02 [1000]	HEAST	CNS	--	D	IRIS
Phenanthrene	--	--	--	--	D	--
Tetrachloroethene	--	--	--	1.8E-03 (f)	B2	HEAST
1,1,1-Trichloroethane	3E-01 [1000]	HEAST	Liver	--	D	--
Trichloroethene	--	--	--	1.7E-02 (g)	B2	HEAST
<b>Inorganics</b>						
Aluminum	--	--	--	--	D	--
Barium	1E-04 [1000]	HEAST	Fetus	--	D	--
Calcium	--	--	--	--	D	--
Copper	--	--	--	--	D	--
Cyanide	--	--	--	--	D	--
Lead	--	--	--	--	B2	IRIS
Mercury (inorganic)	8.57E-05 [30] (d)	HEAST	Nervous system	--	D	--
Silver	--	--	--	--	D	--
Sodium	--	--	--	--	D	--
Zinc	--	--	--	--	D	--

- (a) Uncertainty factors used to develop reference doses generally consist of multiples of 10, with each factor representing a specific area of uncertainty in the data available. The standard uncertainty factors include the following:
- A 10-fold factor to account for the variation in sensitivity among the members of the human population;
  - A 10-fold factor to account for the uncertainty in extrapolation animal data to the case of humans;
  - A 10-fold factor to account for uncertainty in extrapolating from less than chronic NOAELs to chronic NOAELs; and
  - A 10-fold factor to account for the uncertainty in extrapolating from LOAELs to NOAELs.
- (b) A target organ is the organ most sensitive to a chemical's toxic effect. RfDs are based on toxic effects in the target organ. If an RfD was based on a study in which a target organ was not identified, an organ or system known to be affected by the chemical is listed.
- (c) EPA Weight of Evidence for Carcinogenic Effects: [A] = Human carcinogen based on adequate evidence from human studies; [B2] = Probable human carcinogen based on inadequate evidence from human studies and adequate evidence from animal studies; [C] = Possible human carcinogen based on limited evidence from animal studies in the absence of human studies; [D] = Not classified as to human carcinogenicity; and [E] = Evidence of noncarcinogenicity.
- (d) Value reported in mg/m<sup>3</sup> converted to mg/kg-day by assuming that a 70 kg adult inhales air at a rate of 20 m<sup>3</sup>/day.
- (e) Reported as 4.7E-7 (ug/m<sup>3</sup>)-1; assuming a 70 kg individual inhales 20 m<sup>3</sup>/day, this is equivalent to 1.6E-3 (mg/kg/day)-1.
- (f) Reported as 5.2E-7 (ug/m<sup>3</sup>)-1; assuming a 70 kg individual inhales 20 m<sup>3</sup>/day, this is equivalent to 1.8E-3 (mg/kg/day)-1.
- (g) Based on a metabolized dose.

NOTE: IRIS = Integrated Risk Information System - October 1, 1990  
 HEAST = Health Effects Assessment Summary Tables - July 1, 1990  
 EPA = Environmental Protection Agency  
 -- = No information available

AR301501  
 Arrowhead RI  
 May 1, 1991

TABLE 7-40

## SUBCHRONIC ORAL TOXICITY VALUES FOR CHEMICALS OF CONCERN (a)

Chemical	Chronic Reference Dose (mg/kg/day) [Uncertainty Factor] (b)	Target Organ (c)	Reference Dose Source
<b>Organics</b>			
Acetone	1E+00 [100]	Kidney	HEAST
Benzoic acid	4E+00 [1]	Irritation	HEAST
Bis(2-ethylhexyl)phthalate	2E-02 [1000]	Liver	HEAST
1,2-Dichloroethene (total)	2E-01 [100] (d)	Blood serum	HEAST
Methyl ethyl ketone	5E-01 [100]	Fetus	HEAST
Tetrachloroethene	1E-01 [100]	Liver	HEAST
Trichloroethene	--	--	--
<b>Inorganics</b>			
Aluminum	--	--	--
Barium	5E-02 [100]	Blood pressure	HEAST
Cadmium	--	--	--
Calcium	--	--	--
Chromium VI	2E-02 [100]	Not defined	HEAST
Copper	3.7E-02 [1]	GI	HEAST
Cyanide	2E-02 [500]	Thyroid	HEAST
Iron	--	--	--
Lead	--	--	--
Nickel	2E-02 [300]	Body weight	HEAST
Potassium	--	--	--
Silver	3E-03 [2]	Argyria (skin)	HEAST
Sodium	--	--	--
Zinc	2E-01 [10]	Blood (anemia)	HEAST

(a) For pathways involving exposures of less than seven years subchronic RfD values are used.

(b) Uncertainty factors used to develop reference doses generally consist of multiples of 10, with each factor representing a specific area of uncertainty in the data available. The standard uncertainty factors include the following:

A 10-fold factor to account for the variation in sensitivity among the members of the human population; a 10-fold factor to account for the uncertainty in extrapolation animal data to the case of humans; a 10-fold factor to account for uncertainty in extrapolating from less than chronic NOAELs to chronic NOAELs; and a 10-fold factor to account for the uncertainty in extrapolating from LOAELs to NOAELs.

(c) A target organ is the organ most sensitive to a chemical's toxic effect. RfD's are based on toxic effects in the target organ. If an RfD was based on a study in which a target organ was not identified, an organ or system known to be affected by the chemical is listed.

(d) RfD reported is for trans-1,2-dichloroethene.

NOTE: HEAST = Health Effects Assessment Summary Tables - July 1, 1990  
-- = No information available

the hazard index. The hazard index is useful as a reference point for gauging the potential effects of environmental exposures to complex mixtures. In general, hazard indices which are less than one are not likely to be associated with any health risks, and are therefore less likely to be of regulatory concern than hazard indices greater than one. A conclusion should not be categorically drawn, however, that all hazard indices less than one are "acceptable" or that hazard indices greater than one are "unacceptable." This is a consequence of the perhaps one order of magnitude or greater uncertainty inherent in estimates of the RfD and intake, in addition to the fact that the uncertainties associated with the individual terms in the hazard index calculation are additive.

In the absence of specific information on the toxicity of the mixture of chemicals to be assessed or on similar mixtures, EPA guidelines recommend assuming that the effects of different components on the mixtures are additive when affecting a particular organ or system. Synergistic or antagonistic interactions may be taken into account if there is specific information on particular combinations of chemicals. Information on the toxic effects of the specific chemical mixtures at the Arrowhead Plating site are not available. Accordingly, it is assumed in this assessment that the toxic effects of the chemical of potential concern are additive. Thus, lifetime excess cancer risks and the CDI:RfD ratios for individual chemicals are summed to indicate the potential risks associated with mixtures of potential carcinogens and noncarcinogens, respectively. In this assessment, CDI:RfD ratios are summed across all chemicals exhibiting noncarcinogenic effects. If the hazard index resulting from this summation exceeds one, the contribution of chemicals affecting the same target organ is analyzed.

When risk from the dermal absorption of chemicals is quantified, the oral cancer slope factor or reference dose may require modification if it was based upon an administered dose rather than an absorbed dose. The modification required in this case is the absorption efficiency of the chemical under the conditions of the study from which the cancer slope factor was derived. For example, if the slope factor was derived from an animal study where the chemical was administered by gavage, then a factor which represents the extent of absorption of the chemical from the gut under such conditions should be applied. In other cases, the chemical may have been administered during a dietary study. The absorption efficiency used in this situation should reflect the conditions of a dietary study. It should be noted that this type of absorption is different from the relative oral absorption which takes into account differences in absorption of a chemical adsorbed on soil versus the vehicle used in the animal study.

Because most human health effects criteria are based upon administered doses, the extent of absorption under the study conditions is not generally known. In this case, application of an absorption factor would require careful consideration of information from the literature. Because sufficient information regarding this absorption factor was not readily available for the chemicals of concern, an absorption efficiency of 100% (a factor of 1.0) was applied to the oral human health effects criteria when estimating risk through the route of dermal absorption. This assumption may result in an underestimation of risks for chemicals that are not absorbed extensively in the gut. However, this assumption probably is appropriate for most of the volatile organic chemicals at the site, given that these chemicals are likely to be extensively absorbed in the gut.

#### **7.5.1 Potential Risks Associated with the Arrowhead Plating Site**

Risks associated with current and potential future exposures to site-related chemicals in surface soil, ambient air, ground water, surface water, and sediment, are discussed below.

#### **7.5.1.1 Inhalation of Volatile Chemicals in Ambient Air by Workers**

Table 7-41 presents the estimated carcinogenic risks and noncarcinogenic hazards associated with inhalation of volatile chemicals in ambient air by workers, the only complete exposure pathway under the current land-use conditions. The upper-bound excess lifetime cancer risk is  $1 \times 10^{-7}$ , and the hazard index for noncarcinogens is less than 1.

#### **7.5.1.2 Ingestion of Ground Water by Future Residents**

Table 7-42 presents the estimated carcinogenic risks and noncarcinogenic hazards associated with ingestion of chemicals in ground water by future residents. Table 7-42 does not include results of the additional 1991 data. Appendix K summarizes impacts of the new data on the risk assessment. The upper-bound excess lifetime cancer risk is  $8 \times 10^{-2}$ . 1,1-Dichloroethene, tetrachloroethene, and trichloroethene all contribute significantly to the cancer risks for groundwater ingestion. 1,1-Dichloroethene is a Class C carcinogen. As discussed previously, Class C carcinogens are possible human carcinogens, for which limited evidence of carcinogenicity is available. This classification lends uncertainty to predictions of excess lifetime cancer risks associated with this chemical. Tetrachloroethene and trichloroethene have been classified as Class B2, probable human carcinogens.

The hazard index is greater than one due primarily to the same three chemicals that contributed significantly to cancer risk: 1,1-dichloroethene, trichloroethene, and tetrachloroethene. The target organ for all of these chemicals is the liver. The hazard indices for all other target organ groups do not exceed 1.

Although no toxicity criteria are available for lead, EPA's Office of Emergency and Remedial Response and Office of Waste Programs Enforcement have recommended a final cleanup level for lead in ground water of 15  $\mu\text{g/L}$  based on blood lead levels in children (EPA 1990c). The estimated exposure point concentration for lead of 36  $\mu\text{g/L}$  exceeds this cleanup level, indicating that lead in drinking water could contribute to the overall risk to future residents.

As discussed previously, future residents could be exposed via other pathways to the chemicals in ground water during home use of ground water. For example, most of the organic chemicals in ground water are volatile and residents could be exposed via inhalation to chemicals that have volatilized during activities such as showering, cooking and washing clothes. Dermal absorption could result during bathing or washing. Exposure via these pathways would add to overall exposure and risk. The scientific literature on this subject indicates that the risk associated with these sources may be similar in magnitude to that associated with ingestion. For all practical purposes, the risks calculated for ingestion may be doubled to estimate the importance of this effect.

#### **7.5.1.3 Inhalation of Volatile Chemicals in Ambient Air by Future Residents**

Tables 7-43 through 7-46 present the estimated risks to future residents associated with exposure to VOCs via inhalation of ambient air. The upper-bound excess lifetime cancer risks range from  $4 \times 10^{-9}$  to  $1 \times 10^{-7}$  and the hazard indices are all below 1.

#### **7.5.1.4 Dermal Contact and Incidental Ingestion of Surface Soil by Future Residents**

Tables 7-47 through 7-50 present the estimated risks to future residents associated with dermal contact of surface soil from the drum storage, acid tank, chlorinated solvent tank, drain lines,

TABLE 7-41

## POTENTIAL RISKS ASSOCIATED WITH CURRENT INHALATION EXPOSURE AT THE ARROWHEAD PLATING SITE (a)

Chemicals Exhibiting Carcinogenic Effects	Estimated Chronic Daily Intake (CDI) (mg/kg-day)	Slope Factor (mg/kg-day) <sup>-1</sup>	Weight of Evidence Class (b)	Upper Bound Excess Lifetime Cancer Risk
Carbon tetrachloride	7.19E-08	1.3E-01	B2	9E-09
Methylene chloride	6.12E-08	1.6E-03	B2	1E-10
Tetrachloroethene	4.81E-05	1.8E-03	B2	9E-08
Trichloroethene	2.34E-07	1.7E-02	B2	4E-09
TOTAL				1E-07

Chemicals Exhibiting Noncarcinogenic Effects	Estimated Chronic Daily Intake (CDI) (mg/kg-day)	Reference Dose (RfD) (mg/kg-day) (c)	Target Organ (d)	CDI:RfD Ratio
Methyl ethyl ketone	1.06E-06	9E-02 [1000]	CNS	1E-05
Methylene chloride	1.43E-07	9E-02 [1000]	CNS	2E-06
1,1,1-Trichloroethane	1.21E-06	3E-01 [1000]	Liver	4E-06
HAZARD INDEX				<1 (2E-05)

- (a) Chemicals of concern which are not presented due to lack of inhalation toxicity criteria are: acetone, bis(2-ethylhexyl)phthalate, di-n-butylphthalate, trans-1,2-dichloroethene, and phenanthrene.
- (b) EPA Weight of Evidence for Carcinogenic Effects: [B2] = Probable human carcinogen based on inadequate evidence from human studies and adequate evidence from animal studies.
- (c) Uncertainty factors used to develop reference doses generally consist of multiples of 10, with each factor representing a specific area of uncertainty in the data available. The standard uncertainty factors include the following:
- A 10-fold factor to account for the variation in sensitivity among the members of the human population;
  - A 10-fold factor to account for the uncertainty in extrapolation animal data to the case of humans;
  - A 10-fold factor to account for uncertainty in extrapolating from less than chronic NOAELs to chronic NOAELs; and
  - A 10-fold factor to account for the uncertainty in extrapolating from LOAELs to NOAELs.
- (d) A target organ is the organ most sensitive to a chemical's toxic effect. RfDs are based on toxic effects in the target organ. If an RfD was based on a study in which a target organ was not identified, an organ or system known to be affected by the chemical is listed.

TABLE 7-42

POTENTIAL RISKS ASSOCIATED WITH INGESTION OF GROUND WATER BY FUTURE RESIDENTS AT THE ARROWHEAD PLATING SITE (a)

Chemicals Exhibiting Carcinogenic Effects	Estimated Chronic Daily Intake (CDI) (mg/kg-day)	Slope Factor (mg/kg-day) <sup>-1</sup>	Weight of Evidence Class (b)	Upper Bound Excess Lifetime Cancer Risk
Chloroform	1.27E-04	6.1E-03	B2	8E-07
1,1-Dichloroethene	1.06E-01	6.0E-01	C	6E-02
Methylene chloride	3.05E-03	7.5E-03	B2	2E-05
Tetrachloroethene	2.78E-01	5.1E-02	B2	1E-02
Trichloroethene	7.55E-02	1.1E-02	B2	8E-04
TOTAL				8E-02

Chemicals Exhibiting Noncarcinogenic Effects	Estimated Chronic Daily Intake (CDI) (mg/kg-day)	Reference Dose (RfD) (mg/kg-day) (c) [Uncertainty Factor]	Target Organ (d)	CDI:RfD Ratio
Acetone	3.10E-02	1E-01 [1000]	Liver, kidney	3E-01
Barium	5.15E-03	7E-02 [3]	Blood pressure	7E-02
Cadmium	1.46E-04	5E-04 [10] (e)	Kidney	3E-01
Chloroform	2.97E-04	1E-02 [1000]	Liver	3E-02
Chromium (total)	2.85E-03	5E-03 [500] (f)	Nervous system	6E-01
Copper	1.15E-01	3.7E-02 [100] (g)	GI	3E+00
Cyanide	8.31E-04	2E-02 [500]	Thyroid	4E-02
1,1-Dichloroethane	1.35E-03	1E-01 [1000]	Kidney	1E-02
1,1-Dichloroethene	2.46E-01	9E-03 [1000]	Liver	3E+01
1,2-Dichloroethene (total)	1.74E-01	2E-02 [1000]	Blood	9E+00
Mercury (inorganic)	3.96E-06	3E-04 [1000]	Kidney	1E-02
Methylene chloride	7.12E-03	6E-02 [100]	Liver	1E-01
Nickel	3.05E-03	2E-02 [300]	Body weight	2E-01
Silver	2.37E-05	3E-03 [2]	Argyria (skin)	8E-03
Tetrachloroethene	6.49E-01	1E-02 [1000]	Liver	6E+01
1,1,1-Trichloroethane	3.58E+00	9E-02 [1000]	Liver	4E+01
Trichloroethene	1.76E-01	7E-03 [1000]	Liver	2E+01
Zinc	2.02E-02	2E-01 [10]	Anemia	1E-01
HAZARD INDEX				>1 (2E+02)

2E+02

- (a) Chemicals of concern which are not presented due to lack of toxicity criteria are: aluminum, calcium, iron, lead, potassium, and sodium.
- (b) EPA Weight of Evidence for Carcinogenic Effects: [B2] = Probable human carcinogen based on inadequate evidence from human studies and adequate evidence from animal studies; and [C] = Possible human carcinogen based on limited evidence from animal studies in the absence of human studies.
- (c) Uncertainty factors used to develop reference doses generally consist of multiples of 10, with each factor representing a specific area of uncertainty in the data available. The standard uncertainty factors include the following:
- A 10-fold factor to account for the variation in sensitivity among the members of the human population;
  - A 10-fold factor to account for the uncertainty in extrapolation animal data to the case of humans;
  - A 10-fold factor to account for uncertainty in extrapolating from less than chronic NOAELs to chronic NOAELs; and
  - A 10-fold factor to account for the uncertainty in extrapolating from LOAELs to NOAELs.
- (d) A target organ is the organ most sensitive to a chemical's toxic effect. RfDs are based on toxic effects in the target organ. If an RfD was based on a study in which a target organ was not identified, an organ or system known to be affected by the chemical is listed.
- (e) Cadmium RfD for water.
- (f) RfD reported is for chromium VI, as all chromium is conservatively assumed to be in the form of chromium VI.
- (g) Drinking water standard reported in mg/l converted to mg/kg-day by assuming a 70 kg adult consumes 2 liters of water per day.

TABLE 7-43

POTENTIAL RISKS ASSOCIATED WITH INHALATION EXPOSURE IN FUTURE  
RESIDENTS AT THE DRUM STORAGE AREAS (a)

Chemicals Exhibiting Carcinogenic Effects	Estimated Chronic Daily Intake (CDI) (mg/kg-day)	Slope Factor (mg/kg-day) <sup>-1</sup>	Weight of Evidence Class (b)	Upper Bound Excess Lifetime Cancer Risk
Carbon tetrachloride	5.83E-08	1.3E-01	B2	8E-09
Methylene chloride	8.41E-08	1.6E-03	B2	1E-10
Tetrachloroethene	9.93E-07	1.8E-03	B2	2E-09
Trichloroethene	2.28E-07	1.7E-02	B2	4E-09
TOTAL				1E-08

Chemicals Exhibiting Noncarcinogenic Effects	Estimated Chronic Daily Intake (CDI) (mg/kg-day)	Reference Dose (RfD) (mg/kg-day) (c) [Uncertainty Factor]	Target Organ (d)	CDI:RfD Ratio
Methyl ethyl ketone	1.62E-08	9E-02 [1000]	CNS	2E-07
Methylene chloride	1.96E-07	8.57E-01 [100]	Liver	2E-07
1,1,1-Trichloroethane	1.39E-06	3E-01 [1000]	Liver	5E-06
HAZARD INDEX				<1 (5E-06)

- (a) Chemicals of concern which are not presented due to lack of toxicity criteria are: acetone, bis(2-ethylhexyl)phthalate, and di-n-butylphthalate.
- (b) EPA Weight of Evidence for Carcinogenic Effects: [B2] = Probable human carcinogen based on inadequate evidence from human studies and adequate evidence from animal studies.
- (c) Uncertainty factors used to develop reference doses generally consist of multiples of 10, with each factor representing a specific area of uncertainty in the data available. The standard uncertainty factors include the following:
- A 10-fold factor to account for the variation in sensitivity among the members of the human population;
  - A 10-fold factor to account for the uncertainty in extrapolation animal data to the case of humans;
  - A 10-fold factor to account for uncertainty in extrapolating from less than chronic NOAELs to chronic NOAELs; and
  - A 10-fold factor to account for the uncertainty in extrapolating from LOAELs to NOAELs.
- (d) A target organ is the organ most sensitive to a chemical's toxic effect. RfDs are based on toxic effects in the target organ. If an RfD was based on a study in which a target organ was not identified, an organ or system known to be affected by the chemical is listed.

TABLE 7-44

POTENTIAL RISKS ASSOCIATED WITH INHALATION EXPOSURE IN FUTURE  
RESIDENTS AT THE ACID TANK AREA (a)

Chemicals Exhibiting Carcinogenic Effects	Estimated Chronic Daily Intake (CDI) (mg/kg-day)	Slope Factor (mg/kg-day) <sup>-1</sup>	Weight of Evidence Class	Upper Bound Excess Lifetime Cancer Risk
None				

Chemicals Exhibiting Noncarcinogenic Effects	Estimated Chronic Daily Intake (CDI) (mg/kg-day)	Reference Dose (RfD) (mg/kg-day) (b) [Uncertainty Factor]	Target Organ (c)	CDI:RfD Ratio
Methyl ethyl ketone	2.4E-08	9E-02 [1000]	CNS	3E-07
HAZARD INDEX				<1 (3E-07)

- (a) Chemicals of concern which are not presented due to lack of toxicity criteria are: acetone and bis(2-ethylhexyl)phthalate.
- (b) Uncertainty factors used to develop reference doses generally consist of multiples of 10, with each factor representing a specific area of uncertainty in the data available. The standard uncertainty factors include the following:
- A 10-fold factor to account for the variation in sensitivity among the members of the human population;
  - A 10-fold factor to account for the uncertainty in extrapolation animal data to the case of humans;
  - A 10-fold factor to account for uncertainty in extrapolating from less than chronic NOAELs to chronic NOAELs; and
  - A 10-fold factor to account for the uncertainty in extrapolating from LOAELs to NOAELs.
- (c) A target organ is the organ most sensitive to a chemical's toxic effect. RfDs are based on toxic effects in the target organ. If an RfD was based on a study in which a target organ was not identified, the organ listed is one known to be affected by the particular chemical of concern.

TABLE 7-45

POTENTIAL RISKS ASSOCIATED WITH INHALATION EXPOSURE IN FUTURE  
RESIDENTS AT THE SOLVENT TANK AREA (a)

Chemicals Exhibiting Carcinogenic Effects	Estimated Chronic Daily Intake (CDI) (mg/kg-day)	Slope Factor (mg/kg-day) <sup>-1</sup>	Weight of Evidence Class (b)	Upper Bound Excess Lifetime Cancer Risk
Tetrachloroethene	5.29E-05	1.8E-03	B2	1E-07
TOTAL				1E-07

Chemicals Exhibiting Noncarcinogenic Effects	Estimated Chronic Daily Intake (CDI) (mg/kg-day)	Reference Dose (RfD) (mg/kg-day) (c) [Uncertainty Factor]	Target Organ (d)	CDI:RfD Ratio
1,1,1-Trichloroethane	1.98E-06	3E-01 [1000]	Liver	7E-06
HAZARD INDEX				<1 (7E-06)

- (a) Chemicals of concern which are not presented due to lack of toxicity criteria are: acetone and phenanthrene.
- (b) EPA Weight of Evidence for Carcinogenic Effects: [B2] = Probable human carcinogen based on inadequate evidence from human studies and adequate evidence from animal studies.
- (c) Uncertainty factors used to develop reference doses generally consist of multiples of 10, with each factor representing a specific area of uncertainty in the data available. The standard uncertainty factors include the following:
- A 10-fold factor to account for the variation in sensitivity among the members of the human population;
  - A 10-fold factor to account for the uncertainty in extrapolation animal data to the case of humans;
  - A 10-fold factor to account for uncertainty in extrapolating from less than chronic NOAELs to chronic NOAELs; and
  - A 10-fold factor to account for the uncertainty in extrapolating from LOAELs to NOAELs.
- (d) A target organ is the organ most sensitive to a chemical's toxic effect. RfDs are based on toxic effects in the target organ. If an RfD was based on a study in which a target organ was not identified, an organ or system known to be affected by the chemical is listed.

TABLE 7-46

POTENTIAL RISKS ASSOCIATED WITH INHALATION EXPOSURE IN FUTURE  
RESIDENTS AT THE STAINED AREA (a)

Chemicals Exhibiting Carcinogenic Effects	Estimated Chronic Daily Intake (CDI) (mg/kg-day)	Slope Factor (mg/kg-day) <sup>-1</sup>	Weight of Evidence Class (b)	Upper Bound Excess Lifetime Cancer Risk
Tetrachloroethene	2.41E-06	1.8E-03	B2	4E-09
TOTAL				4E-09

Chemicals Exhibiting Noncarcinogenic Effects	Estimated Chronic Daily Intake (CDI) (mg/kg-day)	Reference Dose (RfD) (mg/kg-day) [Uncertainty Factor]	Target Organ	CDI:RfD Ratio
None				

(a) Chemicals of concern which are not presented due to lack of toxicity criteria are: acetone and trans-1,2-dichloroethene.

(b) EPA Weight of Evidence for Carcinogenic Effects: [B2] = Probable human carcinogen based on inadequate evidence from human studies and adequate evidence from animal studies.

TABLE 7-47

POTENTIAL RISKS ASSOCIATED WITH DERMAL CONTACT OF SOIL IN DRUM STORAGE  
AREAS BY FUTURE RESIDENTS AT THE ARROWHEAD PLATING SITE (a)

Chemicals Exhibiting Carcinogenic Effects	Estimated Chronic Daily Intake (CDI) (mg/kg-day)	Slope Factor (mg/kg-day) <sup>-1</sup>	Weight of Evidence Class (b)	Upper Bound Excess Lifetime Cancer Risk
Bis(2-ethylhexyl)phthalate	6.21E-08	1.4E-02	B2	9E-10
Carbon tetrachloride	3.45E-09	1.3E-01	B2	4E-10
Methylene chloride	2.93E-09	7.5E-03	B2	2E-11
Tetrachloroethene	5.35E-08	5.1E-02	B2	3E-09
Trichloroethene	1.12E-08	1.1E-02	B2	1E-10
TOTAL				4E-09

Chemicals Exhibiting Noncarcinogenic Effects	Estimated Chronic Daily Intake (CDI) (mg/kg-day)	Reference Dose (RfD) (mg/kg-day) (c) [Uncertainty Factor]	Target Organ (d)	CDI:RfD Ratio
Acetone	5.43E-08	1E-01 [1000]	Liver, kidney	5E-07
Bis(2-ethylhexyl)phthalate	1.45E-07	2E-02 [1000]	Liver	7E-06
Carbon tetrachloride	8.05E-09	7E-04 [1000]	Liver	1E-05
Cyanide	1.75E-04	2E-02 [500]	Thyroid	9E-03
Di-n-butylphthalate	6.84E-07	1E-01 [1000]	Mortality	7E-06
Methyl ethyl ketone	2.21E-08	5E-02 [1000]	Fetus	4E-07
Methylene chloride	6.84E-09	6E-02 [100]	Liver	1E-07
Tetrachloroethene	1.25E-07	1E-02 [1000]	Liver	1E-05
1,1,1-Trichloroethane	2.82E-08	9E-02 [1000]	Liver	3E-07
Trichloroethene	2.62E-08	7.35E-03 [1000]	Liver	4E-06
HAZARD INDEX				<1 (9E-03)

- (a) Chemicals of concern which are not presented due to lack of toxicity criteria are: aluminum, calcium, lead, potassium, and sodium.
- (b) EPA Weight of Evidence for Carcinogenic Effects: [B2] = Probable human carcinogen based on inadequate evidence from human studies and adequate evidence from animal studies.
- (c) Uncertainty factors used to develop reference doses generally consist of multiples of 10, with each factor representing a specific area of uncertainty in the data available. The standard uncertainty factors include the following:
- A 10-fold factor to account for the variation in sensitivity among the members of the human population;
  - A 10-fold factor to account for the uncertainty in extrapolation animal data to the case of humans;
  - A 10-fold factor to account for uncertainty in extrapolating from less than chronic NOAELs to chronic NOAELs; and
  - A 10-fold factor to account for the uncertainty in extrapolating from LOAELs to NOAELs.
- (d) A target organ is the organ most sensitive to a chemical's toxic effect. RfDs are based on toxic effects in the target organ. If an RfD was based on a study in which a target organ was not identified, an organ or system known to be affected by the chemical is listed.
- (e) Drinking water standard reported in mg/l converted to mg/kg-day by assuming a 70 kg adult consumes 2 liters of water per day.

TABLE 7-48

POTENTIAL RISKS ASSOCIATED WITH DERMAL CONTACT OF ACID TANK  
AREA SOIL BY FUTURE RESIDENTS AT THE ARROWHEAD PLATING SITE (a)

Chemicals Exhibiting Carcinogenic Effects	Estimated Chronic Daily Intake (CDI) (mg/kg-day)	Slope Factor (mg/kg-day) <sup>-1</sup>	Weight of Evidence Class (b)	Upper Bound Excess Lifetime Cancer Risk
Bis(2-ethylhexyl)phthalate	5.18E-08	1.4E-02	B2	7E-10
TOTAL				----- 7E-10

Chemicals Exhibiting Noncarcinogenic Effects	Estimated Chronic Daily Intake (CDI) (mg/kg-day)	Reference Dose (RfD) (mg/kg-day) (c) [Uncertainty Factor]	Target Organ (d)	CDI:RfD Ratio
Acetone	1.97E-07	1E-01 [1000]	Liver, kidney	2E-06
Bis(2-ethylhexyl)phthalate	1.21E-07	2E-02 [1000]	Liver	6E-06
Cyanide	1.41E-05	2E-02 [500]	Thyroid	7E-04
Mercury (inorganic)	0.00E+00	3E-04 [1000]	Kidney	0E+00
Methyl ethyl ketone	3.22E-08	5E-02 [1000]	Fetus	6E-07
HAZARD INDEX				----- <1 (7E-04)

- (a) Chemicals of concern which are not reported due to lack of toxicity criteria are: calcium.
- (b) EPA Weight of Evidence for Carcinogenic Effects: [B2] = Probable human carcinogen based on inadequate evidence from human studies and adequate evidence from animal studies.
- (c) Uncertainty factors used to develop reference doses generally consist of multiples of 10, with each factor representing a specific area of uncertainty in the data available. The standard uncertainty factors include the following:
- A 10-fold factor to account for the variation in sensitivity among the members of the human population;
  - A 10-fold factor to account for the uncertainty in extrapolation animal data to the case of humans;
  - A 10-fold factor to account for uncertainty in extrapolating from less than chronic NOAELs to chronic NOAELs; and
  - A 10-fold factor to account for the uncertainty in extrapolating from LOAELs to NOAELs.
- (d) A target organ is the organ most sensitive to a chemical's toxic effect. RfDs are based on toxic effects in the target organ. If an RfD was based on a study in which a target organ was not identified, an organ or a system known to be affected by the chemical is listed.
- (e) Drinking water standard reported in mg/l converted to mg/kg-day by assuming a 70 kg adult consumes 2 liters of water per day.

TABLE 7-49

POTENTIAL RISKS ASSOCIATED WITH DERMAL CONTACT OF SOLVENT TANK  
AREA SOIL BY FUTURE RESIDENTS AT THE ARROWHEAD PLATING SITE (a)

Chemicals Exhibiting Carcinogenic Effects	Estimated Chronic Daily Intake (CDI) (mg/kg-day)	Slope Factor (mg/kg-day) <sup>-1</sup>	Weight of Evidence Class (b)	Upper Bound Excess Lifetime Cancer Risk
Tetrachloroethene	2.85E-06	5.1E-02	B2	1E-07
TOTAL				1E-07

Chemicals Exhibiting Noncarcinogenic Effects	Estimated Chronic Daily Intake (CDI) (mg/kg-day)	Reference Dose (RfD) (mg/kg-day) (c) [Uncertainty Factor]	Target Organ (d)	CDI:RfD Ratio
Acetone	6.44E-06	1E-01 [1,000]	Liver, kidney	6E-05
Phenanthrene	2.82E-07	4E-03 [10000] (g)	Eye	7E-05
Tetrachloroethene	6.64E-06	1E-02 [1000]	Liver	7E-04
1,1,1-Trichloroethane	4.03E-08	9E-02 [1000]	Liver	4E-07
HAZARD INDEX				<1 (8E-04)

- (a) Chemicals of concern which are not presented due to lack of toxicity criteria are: aluminum, calcium, and lead.
- (b) EPA Weight of Evidence for Carcinogenic Effects: [B2] = Probable human carcinogen based on inadequate evidence from human studies and adequate evidence from animal studies.
- (c) Uncertainty factors used to develop reference doses generally consist of multiples of 10, with each factor representing a specific area of uncertainty in the data available. The standard uncertainty factors include the following:
- A 10-fold factor to account for the variation in sensitivity among the members of the human population;
  - A 10-fold factor to account for the uncertainty in extrapolation animal data to the case of humans;
  - A 10-fold factor to account for uncertainty in extrapolating from less than chronic NOAELs to chronic NOAELs; and
  - A 10-fold factor to account for the uncertainty in extrapolating from LOAELs to NOAELs.
- (d) A target organ is the organ most sensitive to a chemical's toxic effect. RfDs are based on toxic effects in the target organ. If an RfD was based on a study in which a target organ was not identified, an organ or system known to be affected by the chemical is listed.
- (e) The RfD reported is based on food studies.
- (f) Drinking water standard reported in mg/l converted to mg/kg-day by assuming a 70 kg adult consumes 2 liters of water per day.
- (g) The RfD for naphthalene is used in the absence of toxicity criteria for phenanthrene.

TABLE 7-50

POTENTIAL RISKS ASSOCIATED WITH DERMAL CONTACT OF STAINED  
AREA SOIL BY FUTURE RESIDENTS AT THE ARROWHEAD PLATING SITE

Chemicals Exhibiting Carcinogenic Effects	Estimated Chronic Daily Intake (CDI) (mg/kg-day)	Slope Factor (mg/kg-day) <sup>-1</sup>	Weight of Evidence Class (a)	Upper Bound Excess Lifetime Cancer Risk
Bis(2-ethylhexyl)phthalate	3.11E-07	1.4E-02	B2	4E-09
Tetrachloroethene	1.29E-07	5.1E-02	B2	7E-09
TOTAL				----- 1E-08

Chemicals Exhibiting Noncarcinogenic Effects	Estimated Chronic Daily Intake (CDI) (mg/kg-day)	Reference Dose (RfD) (mg/kg-day) (b) [Uncertainty Factor]	Target Organ (c)	CDI:RfD Ratio
Bis(2-ethylhexyl)phthalate	7.25E-07	2E-02 [1000]	Liver	4E-05
1,2-Dichloroethene	1.17E-06	2E-02 [1000]	Blood	6E-05
Tetrachloroethene	3.02E-07	1E-02 [1000]	Liver	3E-05
HAZARD INDEX				----- <1 (1E-04)

- (a) EPA Weight of Evidence for Carcinogenic Effects: [B2] = Probable human carcinogen based on inadequate evidence from human studies and adequate evidence from animal studies.
- (b) Uncertainty factors used to develop reference doses generally consist of multiples of 10, with each factor representing a specific area of uncertainty in the data available. The standard uncertainty factors include the following:
- A 10-fold factor to account for the variation in sensitivity among the members of the human population;
  - A 10-fold factor to account for the uncertainty in extrapolation animal data to the case of humans;
  - A 10-fold factor to account for uncertainty in extrapolating from less than chronic NOAELs to chronic NOAELs; and
  - A 10-fold factor to account for the uncertainty in extrapolating from LOAELs to NOAELs.
- (c) A target organ is the organ most sensitive to a chemical's toxic effect. RfDs are based on toxic effects in the target organ. If an RfD was based on a study in which a target organ was not identified, an organ or system known to be affected by the chemical is listed.

and stained areas. The upper-bound excess lifetime cancer risks range from  $7 \times 10^{-10}$  to  $1 \times 10^{-7}$  and the hazard indices are all below one.

Table 7-51 through 7-55 present the estimated risks to future residents associated with incidental ingestion of surface soil from each area. The upper-bound excess lifetime cancer risks range from  $6 \times 10^{-10}$  to  $8 \times 10^{-8}$ . The hazard indices are all below 1.

If risks from dermal contact and incidental ingestion are summed for each area, the total upper-bound excess lifetime cancer risks range from  $1 \times 10^{-9}$  to  $2 \times 10^{-7}$ , and the hazard indices are all below one.

Although no toxicity criteria are available for lead, EPA's Office of Emergency and Remedial Response and Office of Waste Programs Enforcement have established an interim soil cleanup level for lead at Fund-lead and Enforcement-lead CERCLA sites (EPA 1989c). The cleanup level range, 500 to 1,000 mg/kg, is considered protective for direct contact exposures at residential exposures based on guidance from the Centers for Disease Control (CDC). The exposure point concentration for lead in surface soil at the Arrowhead Plating site range from 8.2 to 18.6 mg/kg. Since this level is well below the health-based cleanup level, adverse effects from direct contact with lead in surface soil are not expected.

#### *7.5.1.5 Dermal Contact of Surface Water and Sediment by Wading Children*

The risks to wading children via dermal contact of surface water are presented in Table 7-56. The upper-bound excess lifetime cancer risk is  $8 \times 10^{-9}$ , and the hazard index is less than 1.

Table 7-57 presents the estimated risks associated with direct contact exposures with sediment for children wading in surface water. The upper-bound excess lifetime cancer risk is  $1 \times 10^{-10}$  and the hazard index is less than one.

The total upper-bound excess lifetime cancer risk for dermal contact of surface water and sediment is  $8 \times 10^{-9}$ , and the hazard index is less than one.

#### *7.5.1.6 Sum of Potential Future Risks*

Future residents could be exposed to chemicals via a combination of pathways, and therefore the future risk associated with exposure via all of the pathways is estimated by summing the risks across the residential pathways. Table 7-58 summarizes the excess lifetime cancer risks and hazard indices for the future exposure pathways evaluated.

Under the future land use condition of residential development, the total excess lifetime cancer risk for each source area is  $8 \times 10^{-2}$ , due entirely to the ground water ingestion pathway. (This risk estimate does not include 1991 sampling data, in which additional chemicals were detected. See Appendix K.) This risk exceeds the target risk level of  $10^{-6}$ . The total hazard indices exceed one, again due entirely to groundwater ingestion. A hazard index of one is the target level used by regulatory agencies. If future ingestion of ground water is eliminated, the risks are all within the target risk level, and the hazard indices are all below one. It is therefore apparent that the only pathway (and medium) which presents a current or future risk to human health is ground water ingestion. Chemicals in surface soil or sediment do not contribute appreciably to the overall risks associated with the site.

TABLE 7-51

POTENTIAL RISKS ASSOCIATED WITH INCIDENTAL INGESTION OF SOIL IN DRUM STORAGE  
AREAS BY FUTURE RESIDENTS AT THE ARROWHEAD PLATING SITE (a)

Chemicals Exhibiting Carcinogenic Effects	Estimated Chronic Daily Intake (CDI) (mg/kg-day)	Slope Factor (mg/kg-day) <sup>-1</sup>	Weight of Evidence Class (b)	Upper Bound Excess Lifetime Cancer Risk
Bis(2-ethylhexyl)phthalate	5.35E-08	1.4E-02	B2	7E-10
Carbon tetrachloride	1.78E-09	1.3E-01	B2	2E-10
Methylene chloride	1.52E-09	7.5E-03	B2	1E-11
Tetrachloroethene	2.77E-08	5.1E-02	B2	1E-09
Trichloroethene	5.80E-09	1.1E-02	B2	6E-11
TOTAL				----- 2E-09

Chemicals Exhibiting Noncarcinogenic Effects	Estimated Chronic Daily Intake (CDI) (mg/kg-day)	Reference Dose (RfD) (mg/kg-day) (c) [Uncertainty Factor]	Target Organ (d)	CDI:RfD Ratio
Acetone	2.81E-08	1.0E-01 [1000]	Liver, kidney	3E-07
Barium	1.51E-05	7.0E-02 [3]	Blood pressure	2E-04
Bis(2-ethylhexyl)phthalate	1.25E-07	2.0E-02 [1000]	Liver	6E-06
Carbon tetrachloride	4.16E-09	7.0E-04 [1000]	Liver	6E-06
Chromium	3.44E-08	5.0E-03 [500]	Nervous system	7E-06
Copper	2.07E-05	3.7E-02 (e)	GI	6E-04
Cyanide	1.81E-06	2.0E-02 [500]	Thyroid	9E-05
Di-n-butylphthalate	3.54E-07	1.0E-01 [1000]	Mortality	4E-06
Methyl ethyl ketone	1.15E-08	5.0E-02 [1000]	Fetus	2E-07
Methylene chloride	3.54E-09	6.0E-02 [100]	Liver	6E-08
Nickel	2.85E-07	2.0E-02 [300]	Body weight	1E-05
Silver	3.44E-08	3.0E-03 [2]	Argyria (skin)	1E-05
Tetrachloroethene	6.45E-08	1.0E-02 [1000]	Liver	6E-06
1,1,1-Trichloroethane	1.46E-08	9.0E-02 [1000]	Liver	2E-07
Trichloroethene	1.35E-08	7.35E-03 [1000]	Liver	2E-06
Zinc	6.35E-06	2.0E-01 [10]	Anemia	3E-05
HAZARD INDEX				----- <1 (1E-03)

- (a) Chemicals of concern which are not presented due to lack of toxicity criteria are: aluminum, calcium, lead, potassium, and sodium.
- (b) EPA Weight of Evidence for Carcinogenic Effects: [B2] = Probable human carcinogen based on inadequate evidence from human studies and adequate evidence from animal studies.
- (c) Uncertainty factors used to develop reference doses generally consist of multiples of 10, with each factor representing a specific area of uncertainty in the data available. The standard uncertainty factors include the following:
- A 10-fold factor to account for the variation in sensitivity among the members of the human population;
  - A 10-fold factor to account for the uncertainty in extrapolation animal data to the case of humans;
  - A 10-fold factor to account for uncertainty in extrapolating from less than chronic NOAELs to chronic NOAELs; and
  - A 10-fold factor to account for the uncertainty in extrapolating from LOAELs to NOAELs.
- (d) A target organ is the organ most sensitive to a chemical's toxic effect. RfDs are based on toxic effects in the target organ. If an RfD was based on a study in which a target organ was not identified, an organ or system known to be affected by the chemical is listed.
- (e) Drinking water standard reported in mg/l converted to mg/kg-day by assuming a 70 kg adult consumes 2 liters of water per day.

TABLE 7-52

POTENTIAL RISKS ASSOCIATED WITH INCIDENTAL INGESTION OF ACID TANK  
AREA SOIL BY FUTURE RESIDENTS AT THE ARROWHEAD PLATING SITE (a)

Chemicals Exhibiting Carcinogenic Effects	Estimated Chronic Daily Intake (CDI) (mg/kg-day)	Slope Factor (mg/kg-day) <sup>-1</sup>	Weight of Evidence Class (b)	Upper Bound Excess Lifetime Cancer Risk
Bis(2-ethylhexyl)phthalate	4.46E-08	1.4E-02	B2	6E-10
TOTAL				6E-10

Chemicals Exhibiting Noncarcinogenic Effects	Estimated Chronic Daily Intake (CDI) (mg/kg-day)	Reference Dose (RfD) (mg/kg-day) (c) [Uncertainty Factor]	Target Organ (d)	CDI:RfD Ratio
Acetone	1.02E-07	1E-01 [1000]	Liver, kidney	1E-06
Barium	2.04E-05	7E-02 [3]	Blood pressure	3E-04
Bis(2-ethylhexyl)phthalate	1.04E-07	2E-02 [1000]	Liver	5E-06
Chromium	5.93E-08	5E-03 [500]	Nervous system	1E-05
Copper	4.21E-06	3.7E-02 (e)	GI	1E-04
Cyanide	1.46E-07	2E-02 [500]	Thyroid	7E-06
Mercury (inorganic)	2.29E-08	3E-04 [1000]	Kidney	8E-05
Methyl ethyl ketone	1.67E-08	5E-02 [1000]	Fetus	3E-07
Nickel	4.75E-07	2E-02 [300]	Body weight	2E-05
Zinc	5.34E-06	2E-01 [10]	Anemia	3E-05
HAZARD INDEX				<1 (5E-04)

- a) Chemicals of concern which are not presented due to lack of toxicity criteria are: aluminum, calcium, lead, potassium, and sodium.
- (b) EPA Weight of Evidence for Carcinogenic Effects: [B2] = Probable human carcinogen based on inadequate human studies and adequate evidence from animal studies.
- (c) Uncertainty factors used to develop reference doses generally consist of multiples of 10, with each factor representing a specific area of uncertainty in the data available. The standard uncertainty factors include the following:
- A 10-fold factor to account for the variation in sensitivity among the members of the human population;
  - A 10-fold factor to account for the uncertainty in extrapolation animal data to the case of humans;
  - A 10-fold factor to account for uncertainty in extrapolating from less than chronic NOAELs to chronic NOAELs; and
  - A 10-fold factor to account for the uncertainty in extrapolating from LOAELs to NOAELs.
- (d) A target organ is the organ most sensitive to a chemical's toxic effect. RfDs are based on toxic effects in the target organ. If an RfD was based on a study in which a target organ was not identified, an organ or system known to be affected by the chemical is listed.
- (e) Drinking water standard reported in mg/L converted to mg/kg-day by assuming a 70 kg adult consumes 2 liters of water per day.

TABLE 7-53

POTENTIAL RISKS ASSOCIATED WITH INCIDENTAL INGESTION OF SOLVENT TANK  
AREA SOIL BY FUTURE RESIDENTS AT THE ARROWHEAD PLATING SITE (a)

Chemicals Exhibiting Carcinogenic Effects	Estimated Chronic Daily Intake (CDI) (mg/kg-day)	Slope Factor (mg/kg-day) <sup>-1</sup>	Weight of Evidence Class (b)	Upper Bound Excess Lifetime Cancer Risk
Tetrachloroethene	1.47E-06	5.1E-02	B2	8E-08
TOTAL				8E-08

Chemicals Exhibiting Noncarcinogenic Effects	Estimated Chronic Daily Intake (CDI) (mg/kg-day)	Reference Dose (RfD) (mg/kg-day) (c) [Uncertainty Factor]	Target Organ (d)	CDI:RfD Ratio
Acetone	3.33E-06	1E-01 [1000]	Liver, kidney	3E-05
Barium	4.14E-05	7E-02 [3]	Blood pressure	6E-04
Cadmium	1.15E-07	1E-03 [10] (e)	Kidney	1E-04
Chromium	4.06E-08	5E-03 [500]	Nervous system	8E-06
Copper	8.93E-04	3.7E-02 (f)	GI	2E-02
Mercury (inorganic)	7.33E-07	3E-04 [1000]	Kidney	2E-03
Nickel	7.30E-07	2E-02 [300]	Body weight	4E-05
Phenanthrene	1.46E-07	4E-03 [10000] (g)	Eye	4E-05
Silver	5.73E-08	3E-03 [2]	Argyria (skin)	2E-05
Tetrachloroethene	3.44E-06	1E-02 [1000]	Liver	3E-04
1,1,1-Trichloroethane	2.08E-08	9E-02 [1000]	Liver	2E-07
Zinc	8.97E-05	2E-01 [10]	Anemia	4E-04
HAZARD INDEX				<1 (3E-02)

- (a) Chemicals of concern which are not presented due to lack of toxicity criteria are: aluminum, calcium, lead, potassium, and sodium.
- (b) EPA Weight of Evidence for Carcinogenic Effects: [B2] = Probable human carcinogen based on inadequate evidence from human studies and adequate evidence from animal studies.
- (c) Uncertainty factors used to develop reference doses generally consist of multiples of 10, with each factor representing a specific area of uncertainty in the data available. The standard uncertainty factors include the following:
- A 10-fold factor to account for the variation in sensitivity among the members of the human population;
  - A 10-fold factor to account for the uncertainty in extrapolation animal data to the case of humans;
  - A 10-fold factor to account for uncertainty in extrapolating from less than chronic NOAELs to chronic NOAELs; and
  - A 10-fold factor to account for the uncertainty in extrapolating from LOAELs to NOAELs.
- (d) A target organ is the organ most sensitive to a chemical's toxic effect. RfDs are based on toxic effects in the target organ. If an RfD was based on a study in which a target organ was not identified, an organ or system known to be affected by the chemical is listed.
- (e) Cadmium RfD for food.
- (f) Drinking water standard reported in mg/l converted to mg/kg-day by assuming a 70 kg adult consumes 2 liters of water per day.
- (g) The RfD for naphthalene is used in the absence of toxicity criteria for phenanthrene.

TABLE 7-54

POTENTIAL RISKS ASSOCIATED WITH INCIDENTAL INGESTION OF DRAIN LINES  
AREA SOIL BY FUTURE RESIDENTS AT THE ARROWHEAD PLATING SITE (a)

Chemicals Exhibiting Carcinogenic Effects	Estimated Chronic Daily Intake (CDI) (mg/kg-day)	Slope Factor (mg/kg-day) <sup>-1</sup>	Weight of Evidence Class	Upper Bound Excess Lifetime Cancer Risk
None				
Chemicals Exhibiting Noncarcinogenic Effects	Estimated Chronic Daily Intake (CDI) (mg/kg-day)	Reference Dose (RfD) (mg/kg-day) (b) [Uncertainty Factor]	Target Organ (c)	CDI:RfD Ratio
Barium	1.04E-05	7E-02 [3]	Blood pressure	1E-04
Chromium	3.90E-08	5E-03 [500]	Nervous system	8E-06
Copper	5.84E-07	3.7E-02 (d)	GI	2E-05
Mercury (inorganic)	1.15E-08	3E-04 [1000]	Kidney	4E-05
Nickel	2.80E-07	2E-02 [300]	Body weight	1E-05
Zinc	1.55E-06	2E-01 [10]	Anemia	8E-06
HAZARD INDEX				<1 (2E-04)

- (a) Chemicals of concern which are not presented due to lack of toxicity criteria are: aluminum, calcium, lead, potassium, and sodium.
- (b) Uncertainty factors used to develop reference doses generally consist of multiples of 10, with each factor representing a specific area of uncertainty in the data available. The standard uncertainty factors include the following:
- A 10-fold factor to account for the variation in sensitivity among the members of the human population;
  - A 10-fold factor to account for the uncertainty in extrapolation animal data to the case of humans;
  - A 10-fold factor to account for uncertainty in extrapolating from less than chronic NOAELs to chronic NOAELs; and
  - A 10-fold factor to account for the uncertainty in extrapolating from LOAELs to NOAELs.
- (c) A target organ is the organ most sensitive to a chemical's toxic effect. RfDs are based on toxic effects in the target organ. If an RfD was based on a study in which a target organ was not identified, an organ or system known to be affected by the chemical is listed.
- (d) Drinking water standard reported in mg/l converted to mg/kg-day by assuming a 70 kg adult consumes 2 liters of water per day.

TABLE 7-55

POTENTIAL RISKS ASSOCIATED WITH INCIDENTAL INGESTION OF STAINED  
AREA SOIL BY FUTURE RESIDENTS AT THE ARROWHEAD PLATING SITE

Chemicals Exhibiting Carcinogenic Effects	Estimated Chronic Daily Intake (CDI) (mg/kg-day)	Slope Factor (mg/kg-day) <sup>-1</sup>	Weight of Evidence Class (a)	Upper Bound Excess Lifetime Cancer Risk
Bis(2-ethylhexyl)phthalate	2.68E-07	1.4E-02	B2	4E-09
Tetrachloroethene	6.69E-08	5.1E-02	B2	3E-09
TOTAL				----- 7E-09

Chemicals Exhibiting Noncarcinogenic Effects	Estimated Chronic Daily Intake (CDI) (mg/kg-day)	Reference Dose (RfD) (mg/kg-day) (b) [Uncertainty Factor]	Target Organ (c)	RfD:CDI Ratio
Bis(2-ethylhexyl)phthalate	6.25E-07	2E-02 [1000]	Liver	3E-05
1,2-Dichloroethene	6.04E-07	2E-02 [1000]	Blood	3E-05
Tetrachloroethene	1.56E-07	1E-02 [1000]	Liver	2E-05
HAZARD INDEX				----- <1 (8E-05)

(a) EPA Weight of Evidence for Carcinogenic Effects: [B2] = Probable human carcinogen based on inadequate evidence from human studies and adequate evidence from animal studies.

(b) Uncertainty factors used to develop reference doses generally consist of multiples of 10, with each factor representing a specific area of uncertainty in the data available. The standard uncertainty factors include the following:

- A 10-fold factor to account for the variation in sensitivity among the members of the human population;
- A 10-fold factor to account for the uncertainty in extrapolation animal data to the case of humans;
- A 10-fold factor to account for uncertainty in extrapolating from less than chronic NOAELs to chronic NOAELs; and
- A 10-fold factor to account for the uncertainty in extrapolating from LOAELs to NOAELs.

(c) A target organ is the organ most sensitive to a chemical's toxic effect. RfDs are based on toxic effects in the target organ. If an RfD was based on a study in which a target organ was not identified, an organ or system known to be affected by the chemical is listed.

TABLE 7-56

POTENTIAL RISKS TO CHILDREN ASSOCIATED WITH DERMAL CONTACT  
OF SURFACE WATER AT THE ARROWHEAD SITE

Chemicals Exhibiting Potential Carcinogenic Effects	Estimated Subchronic Daily Intake (SDI) (mg/kg-day)	Slope Factor (mg/kg-day) <sup>-1</sup>	Weight of Evidence Class (a)	Upper Bound Excess Lifetime Cancer Risk
Bis(2-ethylhexyl)phthalate	3.19E-08	1.4E-02	B2	4E-10
Tetrachloroethene	1.27E-07	5.1E-02	B2	6E-09
Trichloroethene	1.14E-07	1.1E-02	B2	1E-09
TOTAL				8E-09

Chemicals Exhibiting Potential Noncarcinogenic Effects	Estimated Subchronic Daily Intake (SDI) (mg/kg-day)	Reference Dose (RfD) (b) (mg/kg-day) (c) [Uncertainty Factor]	TARGET ORGAN (d)	SDI:RfD Ratio
Bis(2-ethylhexyl)phthalate	3.72E-07	2E-02 [1000]	Liver	2E-05
Cyanide	4.70E-07	2E-02 [500]	Thyroid	2E-05
1,2-Dichloroethene	9.80E-07	2E-02 [1000] (e)	Blood	5E-05
Tetrachloroethene	1.48E-06	1E-01 [100]	Liver	1E-05
HAZARD INDEX				<1 (1E-04)

- (a) EPA Weight of Evidence for Carcinogenic Effects: [B2] = Probable human carcinogen based on inadequate evidence from human studies.
- (b) For pathways involving exposures of less than seven years, subchronic RfD values are used.
- (c) Uncertainty factors used to develop reference doses generally consist of multiples of 10, with each factor representing a specific area of uncertainty in the data available. The standard uncertainty factors include the following:
- A 10-fold factor to account for the variation in sensitivity among the members of the human population;
  - A 10-fold factor to account for the uncertainty in extrapolation animal data to the case of humans;
  - A 10-fold factor to account for uncertainty in extrapolating from less than chronic NOAELs to chronic NOAELs; and
  - A 10-fold factor to account for the uncertainty in extrapolating from LOAELs to NOAELs.
- (d) A target organ is the organ most sensitive to a chemical's toxic effect. RfDs are based on toxic effects in the target organ. If an RfD was based on a study in which a target organ was not identified, an organ or system known to be affected by the chemical is listed.
- (e) RfD is for trans-1,2-dichloroethene.

TABLE 7-57

POTENTIAL RISKS TO CHILDREN ASSOCIATED WITH DERMAL  
CONTACT OF SEDIMENT AT THE ARROWHEAD PLATING SITE (a)

Chemicals Exhibiting Potential Carcinogenic Effects	Estimated Subchronic Daily Intake (SDI) (mg/kg-day)	Slope Factor (mg/kg-day) <sup>-1</sup>	Weight of Evidence Class (b)	Upper Bound Excess Lifetime Cancer Risk
Bis(2-ethylhexyl)phthalate	6.34E-09	1.4E-02	B2	9E-11
Tetrachloroethene	4.83E-10	5.1E-02	B2	2E-11
Trichloroethene	2.66E-10	1.1E-02	B2	3E-12
TOTAL				1E-10

Chemicals Exhibiting Potential Noncarcinogenic Effects	Estimated Subchronic Daily Intake (SDI) (mg/kg-day)	Reference Dose (RfD) (c) (mg/kg-day) (d) [Uncertainty Factor]	Target Organ (e)	SDI:RfD Ratio
Acetone	4.79E-08	1E+00 [100]	Kidney	5E-08
Benzoic acid	5.14E-07	4E+00 [1]	Irritation	1E-07
Bis(2-ethylhexyl)phthalate	7.40E-08	2E-02 [1000]	Liver	4E-06
1,2-Dichloroethene	2.96E-09	2E-01 [1000] (f)	Blood	1E-08
Methyl ethyl ketone	7.75E-09	5E-01 [100]	Fetus	2E-08
Tetrachloroethene	5.64E-09	1E-01 [100]	Liver	6E-08
HAZARD INDEX				<1 (4E-06)

- (a) Chemicals of concern which are not presented due to lack of toxicity criteria are: calcium and sodium.
- (b) EPA Weight of Evidence for Carcinogenic Effects: [B2] = Probable human carcinogen based on inadequate evidence from human studies and adequate evidence from animal studies.
- (c) For pathways involving exposures of less than seven years, subchronic RfD values are used.
- (d) Uncertainty factors used to develop reference doses generally consist of multiples of 10, with each factor representing a specific area of uncertainty in the data available. The standard uncertainty factors include the following:
- A 10-fold factor to account for the variation in sensitivity among the members of the human population;
  - A 10-fold factor to account for the uncertainty in extrapolation animal data to the case of humans;
  - A 10-fold factor to account for uncertainty in extrapolating from less than chronic NOAELs to chronic NOAELs; and
  - A 10-fold factor to account for the uncertainty in extrapolating from LOAELs to NOAELs.
- (e) A target organ is the organ most sensitive to a chemical's toxic effect. RfDs are based on toxic effects in the target organ. If an RfD was based on a study in which a target organ was not identified, an organ or system known to be affected by the chemical is listed.
- (f) RfD reported is for trans-1,2-dichloroethene.

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TABLE 7-58  
SUMMARY OF EXCESS LIFETIME CANCER RISKS AND HAZARD INDICES FOR THE ARROWHEAD PLATING SITE

Exposure Pathway	Drum Storage Area			Acid Tank Area			Solvent Tank Area			Drain Lines Area			Stained Area		
	Excess Lifetime Cancer Risk	Hazard Index		Excess Lifetime Cancer Risk	Hazard Index		Excess Lifetime Cancer Risk	Hazard Index		Excess Lifetime Cancer Risk	Hazard Index		Excess Lifetime Cancer Risk	Hazard Index	
Ingestion of Ground Water	8E-02	>1		8E-02	>1		8E-02	>1		8E-02	>1		8E-02	>1	
Inhalation of Airborne VOCs	1E-08	<1		--	<1		1E-07	<1		--	<1		4E-09	--	
Dermal Contact and Incidental Ingestion of Surface Soil	6E-09	<1		1E-09	<1		2E-07	<1		--	<1		7E-09	<1	
Dermal Contact of Surface Water and Sediment by Residents (Children)	8E-09	<1		8E-09	<1		8E-09	<1		8E-09	<1		8E-09	<1	
	----	----		----	----		----	----		----	----		----	----	
TOTAL	8E-02	>1		8E-02	>1		8E-02	>1		8E-02	>1		8E-02	>1	

-- = No chemicals exhibiting this effect (carcinogenic or noncarcinogenic) were present in this medium and source area, or inadequate toxicity data to evaluate carcinogenic or noncarcinogenic effects of chemicals present in this medium and source area.

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## 7.5.2 Uncertainties in the Human Health Risk Assessment

As in any risk assessment, the estimates of risk for the Arrowhead Plating site have many associated uncertainties. In general, the primary sources of uncertainty are the following:

- Environmental chemistry, sampling, and analysis;
- Fate and transport modeling;
- Exposure parameter estimation; and
- Toxicological data.

Some of the more important sources of uncertainty in this assessment are discussed below. As a result of these uncertainties, this risk assessment should not be construed as presenting an absolute estimate of risks to human or environmental populations. Rather, it is a generally conservative analysis intended to indicate the potential for adverse impacts to occur.

### 7.5.2.1 *Environmental Chemistry and Analysis*

Uncertainty in the risk assessment was introduced because the additional sampling data collected primarily in 1991 were not incorporated in to the quantitative analysis of risk. These data were not available at the time the quantitative risk assessment was conducted. Qualitative statements regarding implications of these additional data on risk estimates are provided in Appendix K; nevertheless, additional uncertainty was introduced to the quantitative risk estimates provided herein.

The new data revealed three fundamental uncertainties in the risk assessment:

- The surface water background location, ST4, was determined to be downstream of the new MF and SF samples, which contained VOCs. Therefore the station cannot technically be considered a background location. Nevertheless, given its distance from MF and SF locations and the absence of VOCs or other contaminants, the ST4 station does not appear to be affected.
- The presence of previously undetected compounds, such as low levels of vinyl chloride and benzene, in ground water could increase the estimated risk associated with the groundwater ingestion pathway.
- Additionally, the higher concentration of TCE in ground water and surface water could also increase the risks associated with these pathways.

Analytical precision or accuracy errors can also contribute to the uncertainty associated with estimates of exposure and risk. Careful QA/QC of the data prior to use in this risk assessment reduces but cannot eliminate the uncertainty associated with such errors.

### 7.5.2.2 *Fate and Transport Modeling*

There are several sources of uncertainty associated with the volatilization and one-compartment models used to estimate the transport of chemicals from soil to ambient air. Many of these sources of uncertainty are related to the assumptions regarding model input parameters. In most cases, conservative assumptions were made that would result in upper-bound estimates of air concentrations. For example, for the current worker scenario, it was assumed that chemicals volatilizing from soil all over the site are transported to the building and consequently enter the building. This assumption yields a conservative estimate of the indoor air concentration because factors such as wind direction, which would reduce the amount of VOCs and BNAs transported to the building from other areas, were not taken into account. Additional assumptions which may over- or underestimate risk were made regarding the area extent of the volatilization sources.

Assumptions made for other fate and transport pathways also contribute to the uncertainties associated with exposure and risk estimates. For example, an important assumption in this assessment was that chemical concentrations remain constant over the 30 year exposure period. Concentrations of VOCs in surface soil are likely to decrease as a result of physical processes of volatilization and leaching through soil, while concentrations of these chemicals in ground water may increase as leaching through soil continues.

### 7.5.2.3 *Exposure Parameter Estimation*

Assumptions regarding exposure parameters also contribute to uncertainty in exposure estimates and the consequent assessment of risks. For example, uncertainties are associated with assumptions of how often, if at all, an individual would come into contact with the chemicals of concern and the period of time over which such exposures would occur. Conservative assumptions were made regarding periods of exposure and it is possible that these time estimates will overestimate the risks associated with potential exposure to chemicals in the various media evaluated. For example, in the future residential scenario, the assumption that individuals remain at their residence 24 hr/day, 365 days/yr probably overestimates exposure for a large majority of the population, but since this could be an accurate estimate of exposure for a small fraction of the population that might be housebound, it was conservatively used.

Other assumptions used in this assessment (e.g., ingestion of 2 L of water, 48-kg average body weight) are assumed to represent upper bounds of potential exposure and were used in the absence of site-specific data. Risks for certain individuals within an exposed population will be higher or lower depending on their actual drinking water intakes, body weights, etc.

### 7.5.2.4 *Toxicological Data*

The toxicity assessment in this report also contributes to uncertainty. For example, a large degree of uncertainty is associated with the estimated cancer risks for 1,1-dichloroethene, a Class C carcinogen. 1,1-Dichloroethene contributed the greatest proportion of risk for the groundwater ingestion and inhalation pathways. However, Class C carcinogens are regarded only as possible human carcinogens and have only limited evidence of carcinogenicity. Thus, estimates of cancer risk associated with 1,1-dichloroethene could greatly overestimate cancer risks associated with the site.

Toxicological data error is also a large source of uncertainty in this risk assessment. As the U.S. EPA notes in its Guidelines for Carcinogenic Risk Assessment (EPA 1986b); there are major

uncertainties in extrapolating both from animals to humans and from high to low doses. There are important species differences in uptake, metabolism, and organ distribution of carcinogens, as well as species and strain differences in target site susceptibility. Human populations are variable with respect to genetic constitution, diet, occupational and home environment, activity patterns and other cultural factors. The lack of inhalation criteria for some of the chemicals is also an important source of uncertainty. For example, no criteria are available for acetone and bis(2-ethylhexyl)phthalate, both of which are present in 3 out of 4 source areas for which inhalation estimates are calculated. The estimated air concentrations of bis(2-ethylhexyl)phthalate, a BNA, are 2 to 6 orders of magnitude lower than other chemicals concentrations. Thus, this chemical probably would not contribute appreciably to overall risks. The estimated air concentrations for acetone, on the other hand, are comparable to those of other chemicals, and therefore this chemical could potentially contribute to overall risks associated with the inhalation pathway.

There is also a great deal of uncertainty in assessing the toxicity of a mixture of chemicals. In this assessment, the effects of exposure to each chemical present in the environmental media have initially been considered separately. However, these substances occur together at the site, and individuals may be exposed to mixtures of the chemicals. Prediction of how these mixtures of toxicants will interact must be based on an understanding of the mechanisms of such interactions. The interactions of the individual components of chemical mixtures may occur during absorption, distribution, metabolism, excretion, or activity at the receptor site. Individual compounds may interact chemically, yielding a new toxic component or causing a change in the biological availability of an existing component, or may interact by causing different effects at different receptor sites. Suitable data are not currently available to rigorously characterize the effects of chemical mixtures similar to those present at the Arrowhead Plating site. Consequently, as recommended by EPA, chemicals present at the site were assumed to act additively, and potential health risks were evaluated by summing excess cancer risks and calculating hazard indices for chemicals exhibiting carcinogenic and noncarcinogenic effects, respectively. This approach to assessing the risk associated with chemical mixtures assumes that there are no synergistic or antagonistic interactions among the chemicals considered and that all chemicals have the same toxic end points and mechanisms of action. To the extent that these assumptions are incorrect, the actual risk could be under- or over-estimated.

## **7.6 ENVIRONMENTAL ASSESSMENT**

This section assesses the potential risks to nonhuman receptors associated with the chemicals of potential concern at the Arrowhead Plating site. The approaches used in this environmental assessment roughly parallel those used in human health risk assessment. In Section 7.6.1, the environmental setting is described, potential environmental receptors are identified, and indicator species or groups are selected for evaluation. Exposure pathways for the indicator species are identified in Section 7.6.2, and available toxicity data are summarized in Section 7.6.3. Finally, in Section 7.6.4, potential risks are discussed. Risk estimates are limited primarily to the population (species) level because data on community and ecosystem level responses to environmental pollutants generally are lacking. However, wherever possible, the implications of population level impacts on the community or ecosystem are also discussed.

### **7.6.1 Receptor Characterization**

In this section the plant and animal species which occur at or near the Arrowhead Plating site are identified and indicator species or species groups are selected for further evaluation.

#### 7.6.1.1 *Terrestrial Receptors*

The Arrowhead Plating site lies in a rural area of Westmoreland County, Virginia. The majority of the onsite area is disturbed due to past or ongoing site activities. Most of the area immediately surrounding the facility is developed or mowed, and is of limited value as potential habitat. Terrestrial habitats surrounding the property include forests, cultivated and abandoned fields, and wetlands. These habitats are described briefly below.

**Forests.** The upland forests, which are most extensive east of the site, are dominated by American beech, red maple, and red oak. Tulip poplar becomes a prevalent overstory species in areas of lower elevation closer to surface water. Understory species include rhododendron, American holly, dogwood, red cedar, cherry, birch, and *Smilax* spp. Cinquefoil, clover, moss, and grasses are some of the herbs present. May apple occurs in wet drainage areas. Animals likely to inhabit the forests include deer, raccoon, red fox, opossum, and gray squirrel. Feral dogs also reportedly inhabit the area.

**Fields.** Adjacent to the northeast corner of the site boundary is a cultivated field currently planted for corn. Other fields which were planted for hay or abandoned are located near the property as well. These fields which contain a variety of grasses and perennial herbs such as goldenrod, asters, and ragweed, probably provide habitat for field mice, voles, shrews, and cottontail rabbit. Birds which inhabit field and edge habitats include meadowlark, field sparrow, and eastern bluebird. Wild turkey were observed roosting in trees in a field near Weavers Millpond, and tracks were present along a trail leading down to the millpond. Predatory birds such as red-tailed hawk and osprey also occur near the site.

**Wetlands.** A relatively large wetland complex is located northeast of the site. It is comprised of Scates Branch which drains directly from the site to Weavers Millpond, Reeds Swamp and Lawrence Swamp which merge into the millpond at opposite ends, and Pierce Creek which is the millpond's outflow. The wetland complex potentially provides habitat for a variety of terrestrial receptors including amphibians such as frogs and salamanders and reptiles such as turtles and snakes. Bird species which utilize wetland habitats include mallards and black ducks, great blue heron, and numerous songbirds.

#### 7.6.1.2 *Aquatic Receptors*

Surface water in the area consists of small streams which flow into and out of the millpond at the center of the wetland complex described above. Scates Branch and Weavers Millpond are the two surface waters most likely to be potentially impacted by the site, because Scates Branch receives runoff from the site, and it flows from the site directly into Weavers Millpond. It should be noted that the environmental assessment of Scates Branch does not include its tributaries, although these waters would be expected to have the same general characteristics. A brief description of both of these water bodies is presented below.

**Scates Branch.** At its origin near the site, Scates Branch has steep banks which are relatively unvegetated. The stream is approximately 3 to 4 inches deep in this area, and small shallow pools occur throughout portions of the creek. The channel through which the stream flows becomes shallow and broad near sample ST3, and the water flow slows. Based on observations during a Clement site visit in 1990, this is believed to be the first point where flow is low enough for

suspended sediments to settle. ST4, located on a branch which joins Scates Branch below ST3, is considered to be a background station. This tributary stream is relatively fast flowing, with a substrate of mixed mud and sand. ST5 is located on Scates Branch after junction with the tributary. At ST6, located where Scates Branch enters Weavers Millpond, the channel of Scates Branch becomes less defined and is hidden by a thick growth of tall grasses and rushes.

Most of the surface water along Scates Branch is too shallow to support fish populations, and aquatic life along this stream probably is limited to invertebrate species. A benthic survey was conducted by VADWM on April 3, 1990 at three locations along Scates Branch (VADWM 1990). The number of species observed during a 5 minute interval, and the relative abundance of each species, were noted. At a location approximately 100 yards downstream of the confluence with the lumber yard drainage, no aquatic invertebrates were observed. This is believed to be largely due to the extreme scouring and the probable intermittent nature of the stream at this point. At a point about 20 yards upstream of Weavers Millpond, mayflies, caddisflies, crane flies, gastropods, and tadpoles were observed. At a location 300 yards below the millpond, mayflies, caddisflies, crane flies, stoneflies, damselfly nymphs, midges, and amphipods were observed.

**Weavers Millpond.** Weavers Millpond is approximately 12 acres in size and is approximately 1 to 2 feet deep. It is high in suspended solids and is murky, with visibility limited to a few inches beneath the surface. Floating heart is prevalent in shallow millpond. Rushes occur along the banks. Green algae and duckweed are prevalent in the millpond, and grasses predominate along its perimeter.

Numerous fairly large turtles, probably snapping turtles, were observed swimming in the millpond during the site visit in October 1990. Bass reportedly live in millpond, and it is likely that some other warmwater fish (e.g., bluegill), exist as well. Sport and commercial baitfishing occurs in downstream portions of Pierce Creek. Blueback herring, American shad, and hickory shad are believed to migrate through and/or spawn in Pierce Creek. Alewife and striped bass have also been occasionally observed. Further downstream, Pierce Creek joins Nomini Creek which widens into Nomini Bay, which contains a thriving shellfish population.

A complete list of the species that occur or are likely to occur near the Arrowhead Plating site has been compiled by the Virginia Department of Game and Inland Fisheries and is presented in Appendix J.

#### **7.6.1.3 Endangered Species**

Two endangered species which may utilize the area near the site were identified based on information obtained from the Virginia Department of Game and Inland Fisheries (see Appendix C). These are the state endangered eastern tiger salamander (*Ambystoma tigrinum tigrinum*), and the state and Federal endangered bald eagle (*Haliaeetus leucocephalus*). Potential occurrence near the site, and habitat and food preferences for these species are briefly summarized below.

**Eastern tiger salamander.** Salamanders of the genus *Ambystoma* are commonly referred to as mole salamanders, because like moles, they stay underground most of their adult lives, emerging mainly during rainy periods and at night (Conant 1975). They are terrestrial as adults, and feed mainly on earthworms and other invertebrates. In the late winter or early spring, they congregate around surface water bodies to mate and lay their eggs. They may utilize the millpond as breeding

habitat. Scates Branch is not likely to be used as breeding habitat because of its steep, unvegetated banks; eggs are typically deposited in large clusters onto the water's surface, often attached to sticks and emergent vegetation. Eggs hatch into aquatic larvae, which metamorphose into adult form approximately 2 to 4 months after hatching (Stebbins 1962).

**Bald eagle.** Three bald eagle nests are reportedly located within a 4-mile radius of the site. One nest is reported to occur near Pierce Creek less than 0.25 mile downstream from its origin at Weavers Millpond. Another nest is reportedly located further to the northeast on Bumbers Branch approximately 0.5 miles upstream from its juncture with Pierce Creek. A third nest at Cat Point Creek is located across Route 3 about 3.5 miles southeast of the site. The primary food item in the bald eagle's diet is fish. When fish are not available, eagles will prey on small mammals such as rodents and cottontail rabbits, as well as carrion and birds.

#### **7.6.1.4 Selection of Indicator Species**

As the previous discussion indicates, the area surrounding the Arrowhead Plating site supports a variety of plant and animal species. Because of this diversity, it is not feasible to assess impacts to every species potentially affected. A common approach to this problem in ecological assessments is to select "indicator" species or species groups for detailed evaluation and to assume that impacts to these indicators are representative of potential impacts in other species at the site. The selection of indicator species or groups is driven by several factors, including the potential for exposure, and the sensitivity (e.g., endangered species) or susceptibility (e.g., based on habitat requirements or foraging strategies) to chemical exposures. Each of these factors was considered in the selection of indicators at the Arrowhead Plating site.

Of particular concern at the Arrowhead Plating site are the bald eagle and tiger salamander, the two endangered species that occur or may occur near the site. Bald eagles are top predators, and could be exposed to chemicals that accumulate through the food chain. Since the main constituent in the bald eagles' diet is fish, they may be exposed to chemicals which have accumulated in fish tissue. However, none of the chemicals of concern in surface water at the site accumulate appreciably in fish [bioconcentrations factors range from 1 (copper) (EPA 1985a) to 136 (aluminum) (EPA 1988a)]. Furthermore, because eagles have a very large foraging range (i.e., tens of square miles) and because of the limited availability of fish in surface water near the site (i.e., only in Weavers Millpond), bald eagles are not likely to be exposed to any appreciable extent to chemicals associated with the Arrowhead Plating site. Therefore, they are not selected as an indicator species for evaluation.

The threatened eastern tiger salamander is much more likely than bald eagles to be significantly exposed to chemicals associated with the site. Although terrestrial as adults, the embryonic-larval stage is aquatic, and therefore could be exposed directly to chemicals in surface water. Because of the potential for significant exposure, and because of its state endangered status, the eastern tiger salamander is selected as an indicator species.

Aquatic organisms are considered to be excellent indicators of the health of an ecosystem. Unlike terrestrial animals whose range can include a large number of food and water sources, an aquatic organism's habitat is generally limited to a particular lake, pond, or river system. Because their movement is generally restricted to the aquatic system they inhabit, aquatic receptors are more susceptible than most terrestrial species to exposure to chemicals in surface water. Therefore, aquatic receptors as a group are selected as indicators.

Terrestrial receptors could be exposed to chemicals by a variety of pathways (e.g., ingestion of soil or sediment while foraging or grooming, ingestion of food that has accumulated chemicals, inhalation of airborne chemicals). Although the area surrounding the site property contains a diversity of habitats, the disturbed area onsite is not likely to provide habitat or food source for a significant portion of the local wildlife communities. The chemicals of concern at the Arrowhead Plating site do not bioaccumulate extensively, so terrestrial wildlife also is not likely to be significantly exposed via ingestion of contaminated food. The range of terrestrial receptors is generally less restricted than that of aquatic receptors, and they are not likely to be continually exposed to chemicals as are aquatic receptors. Therefore, no terrestrial receptors are selected as indicator species, and the focus of this assessment will be on aquatic receptors.

#### **7.6.2 Potential Exposure Pathways**

In this section, the pathways by which the selected indicator species may be exposed to chemicals of potential concern at the Arrowhead Plating site are discussed.

##### **7.6.2.1 Aquatic Receptors**

Aquatic organisms may be exposed to chemicals of potential concern by direct contact with water and sediment and by ingestion of sediments and food containing chemicals of potential concern. However, exposure and toxicity data (dose-response correlations) are seldom available to assess exposure via all of these pathways. Direct contact with water (e.g., respiration) and sediments are generally the only pathways for which toxicity and risk estimates can be determined. In this assessment, impacts to aquatic life via direct contact with surface water will be evaluated quantitatively. Impacts via direct contact with sediment will be evaluated for those chemicals with available toxicity data.

##### **7.6.2.2 Amphibians (*Eastern Tiger Salamander*)**

Amphibians are susceptible to chemicals in surface water during their aquatic embryo-larval stage. They may be exposed via direct contact with water during the aquatic embryo-larval stage, and via dermal contact with and ingestion of water, sediment, and soil during the terrestrial adult stage. The aquatic embryo-larval stages of amphibians have been shown to be more sensitive to toxic effects of chemicals than the adult stage (Birge et al. 1979). Therefore, impacts to amphibians from exposure of the embryo-larval stage to chemicals in surface water and sediment will be evaluated for those chemicals with available toxicity data. Sample stations ST1 through ST3 do not provide suitable breeding habitat for amphibians (i.e., the banks in these locations are steep and unvegetated); therefore, only surface water and sediment concentrations from ST5 through ST7 will be used in evaluating impacts to the eastern tiger salamander.

#### **7.6.3 Toxicity of Chemicals of Potential Concern**

This section briefly summarizes toxicity data for the chemicals of potential concern and receptors (i.e., aquatic life and amphibians) selected for quantitative evaluation. The procedures used to select critical toxicity values for aquatic life and amphibians are summarized below. Then data regarding toxicity of chemicals in surface water (and sediment where available) are presented for these receptors.

**Aquatic Life.** Chemical-specific ambient water quality criteria (AWQC) have been established by the EPA (1986e) for the protection of aquatic life. These criteria are developed to be protective of 95% of all aquatic species. Not only are fish protected, but aquatic invertebrates and plants are protected as well. Acute AWQC concentrations are intended to be protective against short-term effects such as lethality, and chronic AWQC concentrations are intended to be protective against long-term effects such as impaired reproductive capacity. If the measured one-hour chemical concentration in a particular water body does not exceed the acute AWQC for that chemical, and if the measured 4-day average concentration does not exceed the chronic AWQC, then neither acute nor chronic toxic effects are likely to be observed in the aquatic communities in that water body.

For some inorganic chemicals, toxicity to aquatic life is dependent upon hardness of the surface water, and criteria are presented in the form of an equation which includes water hardness. The geometric mean water hardness at stations ST1 through ST7 was calculated to be 39 mg/L as  $\text{CaCO}_3$ . The equations, which are based on regression analysis, are valid only down to a water hardness of 50 mg/L as  $\text{CaCO}_3$ ; for water hardnesses below 50 mg/L, EPA recommends using the criteria that correspond to a hardness of 50 mg/L as  $\text{CaCO}_3$ .<sup>6</sup> Therefore, for those inorganics with hardness-dependent criteria, a hardness of 50 mg/L as  $\text{CaCO}_3$  was used to calculate the criteria.

If AWQCs have not been established for a particular chemical, then available toxicity data are used to derive critical toxicity criteria. Median lethal concentrations ( $\text{LC}_{50}$ s), acute no-observed-effect concentrations (NOECs), or lowest-observed-effect concentrations (LOECs) are used to derive the acute toxicity criteria, and chronic NOECs or LOECs are used to derive the chronic values. A NOEC is used preferentially if available since it represents the concentration at which no adverse effect was observed. In the absence of a NOEC, if LOEC or  $\text{LC}_{50}$  values are available for four or more genera, then no uncertainty factor is applied to these values; otherwise a factor (divisor) of 10 is applied to provide a reasonable margin of safety. The uncertainty factors are arbitrary values used to reflect the uncertainty in the estimates of the "safe" exposure level. The use of these uncertainty factors is based on an analysis of dose-response data performed by EPA which was used to evaluate potential effects of pesticides on wildlife (Urban and Cook 1986).

If no chronic toxicity data are available for an organic chemical (e.g., 1,2-dichloroethene), a chronic toxicity value is derived by dividing the lowest  $\text{LC}_{50}$  by an acute-to-chronic ratio (ACR) that also takes into account interspecies differences in sensitivity. This ACR was derived by Kenaga (1982) and further supported by the work of Call et al. (1985). Because this work only evaluated ACRs for industrial organic chemicals, it is not appropriate to apply it to inorganic chemicals (e.g., potassium).

Criteria similar to AWQCs have not yet been developed for chemicals in sediments. However, limited data are available which report effects in terms of  $\text{EC}_{50}$ s or NOECs. No uncertainty factors are used to derive sediment critical toxicity values, because an analysis of dose-response data for chemicals in sediments has not been performed, and appropriate uncertainty factors are not known.

**Amphibians (Eastern Tiger Salamander).** Toxicity data for salamanders are limited. Critical toxicity values for embryo-larval stage salamanders exposed to surface water are derived from the available data by applying an appropriate uncertainty factor. The available data are generally reported as  $\text{LC}_{50}$ s or median effect concentrations ( $\text{EC}_{50}$ s). As described above for aquatic life, an

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<sup>6</sup> Stephan, C. 1990. Personal communication, EPA Environmental Research Laboratory, Duluth, MN, April 1990.

uncertainty factor of 10 is applied to these data to provide a reasonable margin of safety for most species. An additional uncertainty factor of 2 is applied in order to provide a greater protection level for the endangered species (Urban and Cook 1986).

The toxicity of these chemicals to aquatic organisms and amphibians is briefly summarized below. Critical toxicity values, which will be used to estimate the potential impacts to aquatic life and amphibians, are identified or derived. Table 7-59 summarizes the critical toxicity values presented in this section.

#### 7.6.3.1 Aluminum

The aquatic toxicity of aluminum is thought to be due to the soluble inorganic forms. Aluminum is amphoteric with minimum solubility at approximately pH 5.5. As pH increases and decreases from 5.5, aluminum solubility increases. Freeman and Everhardt (1971) and Hunter et al. (1980) found that as pH increases, aluminum toxicity to rainbow trout increases. However, Call (1984), Boyd (1979), and Kimball (manuscript) found the opposite in tests using fathead minnows.

Chronic toxicity of aluminum has been tested with *Daphnia magna* (Kimball manuscript) which was found to have a chronic value of 1,388  $\mu\text{g/L}$  after 28 days. Reduced growth rate at a concentration of 7,100  $\mu\text{g/L}$  was reported by Kimball (manuscript) in 28-day (posthatch) embryo-larval tests using fathead minnows. Tests for aquatic phytotoxicity using the alga *Selenastrum capricornutum* found it sensitive to aluminum at a concentration of 460  $\mu\text{g/L}$  (Call 1984).

The acute AWQC for aluminum is 750  $\mu\text{g/L}$  and the chronic AWQC is 87  $\mu\text{g/L}$  (EPA 1988a). These values will be used to evaluate potential impacts to aquatic life.

Birge et al. (1978 in EPA 1988a) reported an 8-day  $\text{EC}_{50}$  (median effect concentration) based on death and deformity of 2,280  $\mu\text{g/L}$  for the marbled salamander *Ambystoma opacum*. By applying an uncertainty factor (divisor) of 20 to this value (10 because it is an  $\text{EC}_{50}$ , and 2 to provide extra protection to an endangered species), a critical toxicity value of 114  $\mu\text{g/L}$  is derived. This value will be used to evaluate potential impacts of aluminum to the eastern tiger salamander.

#### 7.6.3.2 Bis(2-ethylhexyl) phthalate

*Daphnia magna* exposed to bis(2-ethylhexyl)phthalate (DEHP) had an  $\text{LC}_{50}$  of 11,000  $\mu\text{g/L}$ . Chronic toxicity was observed at 8.4  $\mu\text{g/L}$  in rainbow trout (EPA 1987). *Daphnia magna* had significant adverse reproductive effects at 3  $\mu\text{g/L}$  (EPA 1987). EPA (1987) has proposed acute and chronic AWQCs of 400 and 360  $\mu\text{g/L}$ , respectively (see also Federal Register Vol. 55 No. 93, 5/14/90—Notices). These AWQCs will be used to estimate potential impacts of DEHP to aquatic life. No amphibian toxicity data were available which relate water concentrations of DEHP with toxic effects.

Barrick and Beller (1989) report apparent effects thresholds (AETs) of 60 mg/kg DEHP in sediment for both oysters and benthic invertebrates, and an AET of 78 mg/kg DEHP in sediment for amphipods. The lowest AET of 60 mg/kg will be used to estimate potential impacts of DEHP in sediment to aquatic life.

TABLE 7-59

## CRITICAL TOXICITY VALUES FOR INDICATOR SPECIES AT THE ARROWHEAD PLATING SITE (a)

Chemical	Aquatic Life (ug/l)			Salamader
	Surface Water (ug/l)		Sediment (mg/kg)	Surface Water (ug/l)
	Chronic	Acute		
Organics:				
Acetone	--	--	NA	--
Benzoic acid	--	--	NA	--
Bis(2-ethylhexyl)phthalate	360	400	60	NA
1,2-Dichloroethene (total)	46.4	1,160	NA	NA
Methyl ethyl ketone	--	--	NA	--
Tetrachloroethene	84	528	>22	NA
Trichloroethene	2,190	4,500	NA	NA
Inorganics:				
Aluminum	87	750	--	114
Calcium	92,000	NA	NA	NA
Copper (b)	6.5	9.2	--	38
Cyanide	5.2	22	--	NA
Iron	1,000	NA	--	NA
Nickel	--	--	>140	--
Potassium	NA	373,000	--	NA
Sodium	NA	NA	NA	NA

(a) See text for source of values.

(b) Toxicity of this chemical is dependent upon water hardness. Refer to text for equations used to calculate criteria.

An  $EC_{50}$  of 150 mg/kg DEHP in sediment was reported for hatchability of moorfrog (*Rana arvalis*) eggs. Tadpoles which hatched successfully were not adversely affected (Larsson and Thuren 1987). This sediment value will be used to evaluate potential impacts of DEHP to amphibians.

#### 7.6.3.3 Calcium

Calcium is not highly toxic to aquatic life, and therefore EPA has not established protective criteria for calcium. Calcium is one of the polyvalent metallic ions which define water hardness. Thus calcium indirectly affects the toxicity of those chemicals whose toxicity is dependent on water hardness (copper, lead, nickel, silver, and zinc). The following 96-Hour  $LC_{50}$ s were reported in NAS (1973): 160,000  $\mu\text{g/L}$  for *Gambusia affinis* (Wallen et al. 1957), 9,500,000  $\mu\text{g/L}$  for bluegill sunfish (*Lepomis macrochirus*) (Cairns, Jr. and Scheier 1959), 3,130,000  $\mu\text{g/L}$  for *Nitzschia linearis* (5-days) (Patrick et al. 1968), and 7,752,000  $\mu\text{g/L}$  for *Carassius auratus* (1-day) (Jones 1957). Dowden and Bennett (1965) reported a 1-day  $LC_{50}$  of 3,526,000  $\mu\text{g/L}$  for *Daphnia magna*. They also report  $LC_{50}$ s for snail eggs (*Lymnaea* sp.) of 4,485,000, 3,094,000, and 2,373,000  $\mu\text{g/L}$ , following 1-, 2-, and 3-day exposures, respectively. Because data are available for 4 genera, the lowest  $LC_{50}$  of 160,000  $\mu\text{g/L}$  is selected as an acute critical toxicity value. Thresholds of immobilization ranging from 920,000  $\mu\text{g/L}$  for *Daphnia magna* to 22,080,000  $\mu\text{g/L}$  for white fish (sp. not given). By applying an uncertainty factor of 10 to 920,000  $\mu\text{g/L}$  (which is the lowest threshold of immobilization and assumed to be similar to a LOEC), a chronic critical toxicity value of 92,000  $\mu\text{g/L}$  is derived. These values will be used to evaluate potential impacts to aquatic life. Data regarding sediment toxicity were not located, nor were data regarding toxicity to amphibians.

#### 7.6.3.4 Copper

The primary mechanism of copper toxicity in aquatic organisms is osmoregulatory disruption and failure (Rand and Petrocelli 1985). Copper toxicity decreases with increasing water hardness. Data suggest that acclimation increases tolerance to copper. EPA (1986e) recommended that the 4-day average concentration of copper (in  $\mu\text{g/L}$ ) should not exceed the value given by  $e^{(0.8545[\ln(\text{hardness})]-1.465)}$ , and the 1-hour average concentration should not exceed the value given by  $e^{(0.942[\ln(\text{hardness})]-1.464)}$ . The values corresponding to the 4-day and 1-hour average concentrations at a water hardness of 50 mg/L  $\text{CaCO}_3$  are 6.5 and 9.2  $\mu\text{g/L}$ , respectively. These two values are selected as critical toxicity values for evaluating impacts of copper to aquatic life.

An  $EC_{50}$  of 770  $\mu\text{g/L}$  was reported in EPA 1985a for the marbled salamander (*Ambystoma opacum*) following 8 days of exposure. By applying an uncertainty factor of 20, a critical toxicity value of 38  $\mu\text{g/L}$  is derived. This value will be used to evaluate impacts of copper to amphibians.

#### 7.6.3.5 Cyanide

The toxicity of cyanide to aquatic organisms is mainly due to the HCN species. At high concentrations, cyanide has induced death in aquatic invertebrates and fish following acute exposures, and following chronic exposures, can decrease reproduction, impair swimming ability, increase respiration, disrupt osmo- and ionic-regulation, and induce histopathological effects in fish (EPA 1985c). While long-term survival and growth of various freshwater fish species are known to be substantially reduced under conditions of 20-50  $\mu\text{g/L}$  free cyanide, no accumulation or biomagnification in the food chain has been demonstrated (Towill et al. 1978, EPA 1985d). Also, field studies

have demonstrated that despite cyanide-induced mortality among invertebrate fauna, populations of these organisms can rapidly recover in lakes treated with cyanide (Leduc et al. 1973).

EPA (1985c) has established for aquatic organisms and their uses a continuous concentration criterion of 5.2 µg/L and a 1-hour concentration criterion of 22 µg/L for cyanide. These values will be used to evaluate impacts of cyanide to aquatic organisms. No data regarding toxicity to amphibians were available.

#### 7.6.3.6 1,2-Dichloroethene

Limited information is available on the environmental toxicity of dichloroethenes. The location of the chlorine atoms on the molecule does not greatly affect the acute toxicity of dichloroethene (DCE). Bluegill were tested by the EPA (1978) with both 1,1- and 1,2-DCE under similar conditions and the 96-hour LC<sub>50</sub> values under static conditions were 73,900 and 135,000 µg/L respectively. The LOEC for acute toxicity reported by EPA (1986e) is 11,600 µg/L, which is reported for 1,1-DCE. By applying an uncertainty factor of 10 to this value, an acute critical toxicity value of 1,160 µg/L is derived. A LOEC for chronic toxicity was not available. By applying an ACR of 25 to the measured acute LOEC of 11,600 µg/L, an estimated chronic toxicity value of 464 µg/L is calculated. Applying an uncertainty factor of 10 results in a chronic critical toxicity value of 46.4 µg/L. The acute LOEC of 1,160 µg/L and the estimated chronic value of 46.4 µg/L are selected as critical toxicity values for estimating impacts to aquatic life. No data regarding sediment toxicity or toxicity to amphibians were located in the literature.

#### 7.6.3.7 Iron

Ferrous (Fe<sup>+2</sup>) and ferric (Fe<sup>+3</sup>) iron are the species of concern in aquatic systems, although ferric iron is practically insoluble (EPA 1986e). Iron concentrations of 1,000-2,000 µg/L were lethal to Northern pike (*Esox lucius*) and trout (species not known) (Doudoroff and Katz 1953). Precipitates of iron coat the gills and inhibit oxygen uptake, and also create a smothering effect detrimental to fish eggs and bottom-dwelling organisms. EPA has established an AWQC for iron of 1,000 µg/L (EPA 1986e). This value is selected as the critical toxicity value for estimation of impacts to aquatic life.

#### 7.6.3.8 Potassium

Potassium is a major cation in aquatic systems and is a required micronutrient for some aquatic species (Wetzel 1975). LC<sub>50</sub> values of 679,000, 940,000, 1,941,000, and 4,200,000 µg/L have been reported for potassium chloride in *Daphnia magna*, bluegill *Lepomis macrochirus*, snail species (*Lymnaea*), and mosquitofish *Gambusia affinis*, respectively (NAS 1973). A threshold of immobilization has been reported as 373,000 µg/L potassium chloride for *Daphnia magna* (NAS 1973). No AWQC for the protection of freshwater aquatic life have been established for potassium, due to its relatively low toxicity. Because acute toxicity data are available for more than 4 genera, the lowest LC<sub>50</sub> of 679,000 µg/L is selected as the acute critical toxicity value. The acute to chronic ratio of 25 is not used for potassium because it applies only to organic chemicals. Data regarding toxicity to amphibians were not available.

#### 7.6.3.9 Sodium

Sodium is not very toxic to aquatic life. The main toxic effect of excess amounts of sodium is the disruption of osmotic balance in freshwater aquatic organisms. Sodium is one of the major cations that define salinity. The range of salinities an organism can exist in varies among species; some species can tolerate wide variations in the salt concentration of the water in which they exist, while others have a limited tolerance to such variations. Anadromous fish, which generally live in salt water and migrate into freshwater to spawn, undergo chemical changes to adapt to the decrease in salinity (Schmidt-Nielsen 1983). No AWQC have been established for the protection of aquatic life, nor were other toxicity data available.

#### 7.6.3.10 Tetrachloroethene

An ambient water quality criterion has not been established for tetrachloroethene. The LOECs for acute and chronic toxicity to freshwater aquatic life are 5,280 and 840  $\mu\text{g/L}$ , respectively (EPA 1986e). The chronic LOEC is based on an embryo-larval test performed with fathead minnows (*Pimephales promelas*) that gave a Maximum Acceptable Toxicant Concentration (MATC) of 840  $\mu\text{g/L}$  (EPA 1980a). Applying an uncertainty factor of 10 to these values yields acute and chronic toxicity values of 528 and 84  $\mu\text{g/L}$ , respectively. No data regarding amphibian toxicity were reported.

Barrick and Beller (1989) reported sediment values in terms of AETs. They report an AET of  $>22 \text{ mg/kg}$  (in dry weight) for benthic invertebrates, amphipods, and oysters. This AET will be used as a critical toxicity value for sediment in evaluating impacts to aquatic life.

#### 7.6.3.11 Trichloroethene

Insufficient data are available to establish an ambient water quality criteria (EPA 1986e). TCE has shown acute toxicity to freshwater aquatic life at a concentration as low as 45,000  $\mu\text{g/L}$  and acute toxicity could occur at lower concentrations with more sensitive species (EPA 1986e). The chronic LOEC is 21,900  $\mu\text{g/L}$  (EPA 1986e). By applying an uncertainty factor of 10 to these values yields acute and chronic toxicity values of 4,500 and 2,190  $\mu\text{g/L}$ , respectively. No data regarding sediment toxicity or toxicity to amphibians were located.

### 7.6.4 Risk Characterization

This section presents a discussion of the potential risks to aquatic life and amphibians associated with exposure to chemicals of potential concern.

#### 7.6.4.1 Risks to Aquatic Life

Risks to aquatic life are evaluated below by comparing surface water and sediment concentrations with critical toxicity values. In addition, the results of three toxicity tests conducted to support the field investigation are discussed.

**Surface Water.** A comparison of aquatic toxicity values and estimated exposure concentrations is given in Table 7-60. None of the organic chemical concentrations in the surface waters exceed the toxicity criteria for these chemicals. Of the inorganic chemicals for which criteria are available, aluminum and copper concentrations exceed both acute and chronic criteria. The exposure point

TABLE 7-60

COMPARISON OF SURFACE WATER CONCENTRATIONS WITH  
AQUATIC LIFE CRITICAL TOXICITY VALUES

(Concentrations in ug/l)

Chemical	Exposure Point Concentration (a)	Critical Toxicity Value (b)	
		Chronic	Acute
Organics:			
Bis(2-ethylhexyl)phthalate	9.5	360	400
1,2-Dichloroethene (total)	25	46.4	1,160
Tetrachloroethene	37.8	84	528
Trichloroethene	34	2,190	4,500
Inorganics:			
Aluminum	2,395	87	750
Calcium	19,025	92,000	160,000
Copper	10.8	6.5	9.2
Cyanide	12	5.2	22
Iron	5,100	1,000	NA
Potassium	7,700	NA	373,000
Sodium	106,800	NA	NA

- (a) Each concentration listed is the lower of the upper 95th percent confidence limit on the arithmetic mean and the maximum detected concentration.
- (b) In absence of AWQC, lowest observed effect concentrations (LOEC) are presented, if available, to provide an estimate of relative toxicity.
- (c) No toxicity values were available for 1,2-dichloroethene; the value presented here is for 1,1-dichloroethene.
- (d) Toxicity of these chemicals is dependent upon water hardness. Refer to text for equations used to calculate criteria.

concentration for aluminum is over three times higher than the acute toxicity criterion and over 25 times higher than the chronic criterion for this chemical. However, the aluminum concentration of 380 µg/L in the background sample (ST4) also exceeds the chronic criterion. For copper, the exposure point concentration is higher than the toxicity criteria but within the same order of magnitude. The exposure point concentration for cyanide is within the acute criterion but exceeds the chronic criterion (although it is within the same order of magnitude). The exposure point concentration for iron is five times the AWQC for this chemical. The iron concentration in the background sample also exceeds this chemical's AWQC. The elevated concentrations of iron and aluminum in the background sample are probably indicative of local surface water conditions. Although EPA has not established AWQC for sodium, it is an important major cation in aquatic systems and is not considered highly toxic.

It must be noted that the AWQC are conservative values which are intended to be protective of aquatic life. Exceedance of the AWQC does not mean that organisms in a particular surface water body are being negatively impacted; it simply means that there is the potential for negative impacts to some species.

**Sediment.** Criteria similar to AWQC have not yet been established for sediment. Table 7-61 presents a comparison of sediment concentrations with the three available sediment toxicity values. As shown in this table, exposure point concentrations are one to three orders of magnitude below the sediment toxicity values. Since the toxicity values are not exceeded, adverse impacts from exposure to sediments are not expected.

**Toxicity Test Results.** In addition to a chemical analysis of surface water and sediment samples, aquatic toxicity tests also were performed to determine whether the chemicals in these media have the potential to affect survival, growth, or reproduction of aquatic organisms.

Toxicity tests were performed using two aquatic organisms: the fathead minnow (*Pimephales promelas*) and the invertebrate waterflea *Ceriodaphnia dubia*. Two types of analyses were performed: the 7-day fathead minnow survival and growth toxicity test, and the 7-day *C. dubia* survival and reproductive toxicity test. The general methodology for the two tests is similar, in that organisms were maintained in surface water samples or laboratory control water for 7 days, and survival and growth (minnows) or reproductive success (*C. dubia*) were monitored. A statistical comparison of the data was then performed to determine whether survival and growth or reproductive success of the organisms differed significantly between sample and control groups.

Fathead minnows were divided into three groups and maintained for 7 days in (1) surface water collected from ST1, (2) surface water collected from ST6, or (3) laboratory control water. Results of the fathead minnow test, summarized in Table 7-62, showed no significant difference in survival or growth between the test and control groups.

In the *C. dubia* test, organisms were maintained for 7 days in surface water from ST1, surface water from ST6, or laboratory control water. The results of the *C. dubia* tests, also summarized in Table 7-62, showed no effect on survival but significantly decreased reproduction in both ST1 and ST6 surface water samples relative to the laboratory control.

In addition to the tests using surface water, a *C. dubia* test also was performed in which organisms were exposed to sediment elutriate obtained from either ST1, ST6, ST4, or a laboratory

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TABLE 7-61  
COMPARISON OF SEDIMENT CONCENTRATIONS WITH  
AQUATIC LIFE TOXICITY VALUES (a)

Chemical	Exposure Point Concentration (mg/kg)	Aquatic Life Toxicity Value (mg/kg) (b)
Organics:		
Bis(2-ethylhexyl)phthalate	0.35	60
Tetrachloroethene	0.008	>22
Inorganics:		
Nickel	9.2	>140

(a) Chemicals of concern which are not presented due to lack of toxicity data are: acetone, benzoic acid, calcium, 1,2-dichloroethene, methyl ethyl ketone, sodium, and trichloroethene.

TABLE 7-62

## RESULTS OF AQUATIC TOXICITY TESTS

(7-Day Fathead Minnow Larval Survival and Growth Test and  
7-day Ceriodaphnia dubia Reproductive Toxicity Test)

Fathead Minnow Toxicity Test (a)			
Surface Water			
LOCATION:	ST-1	ST-6	LABORATORY CONTROL
pH:	7.5	7.2	8.2
% SURVIVAL:	87.5	92.5	87.5
% GROWTH:	80.7	82.8	79.5

Ceriodaphnia dubia Toxicity Tests			
Surface Water			
LOCATION:	ST-1	ST-6	LABORATORY CONTROL
pH:	7.5	7	8.1
% SURVIVAL:	90	100	100
MEAN # OFFSPRING:	9.9 *	8.2 *	17.9

Sediment Elutriate				
	ST-1	ST-6	FIELD CONTROL (ST-4)	LABORATORY CONTROL
LOCATION:				
pH:	7.5	5.9	4.4	8.1
% SURVIVAL:	40 *	70	0 *	100
MEAN # OFFSPRING:	6.2 *	1.9 *	0 *	17.9

(a) Fathead minnow test was not performed for sediment elutriate.  
 \* = Significantly below laboratory control results.

control. Tests using sediment elutriate showed significantly decreased survival and reproduction in *C. dubia* in all three elutriate samples when compared with the laboratory control. In these tests, the pH values of the sample elutriate at both ST4 and ST6 were unusually low (4.4 and 5.9, respectively). It is probable that the low pH contributed to the negative results for these two samples; however, negative results were also observed in the ST1 sample, which had a pH of 7.5.

The overall results from the toxicity test indicate that effects to aquatic populations may be occurring in surface water near the site because of direct discharge of ground water to the tributaries.

#### **7.6.4.2 Risk to Amphibians**

A comparison of amphibian critical toxicity values (available only for aluminum and copper) and surface water exposure point concentrations (averaged from ST5, 6, and 7) is presented in Table 7-63. The exposure point concentration for copper is lower than the toxicity value, but the exposure point concentration for aluminum exceeds the toxicity value. In addition, a sediment critical toxicity value of 150 mg/kg was derived for DEHP. The arithmetic mean concentration for DEHP is 0.3 mg/kg. Since this concentration is well below the critical toxicity value of 150 mg/kg, potential adverse impacts to amphibians probably should not be attributed to the presence of DEHP in sediment. Because the aluminum concentration in water exceeds the critical toxicity value, the potential exists for adverse impacts to embryo-larval stages of amphibians, including the state endangered eastern tiger salamander, due to the current surface water conditions near the Arrowhead Plating site.

## **7.7 SUMMARY AND CONCLUSIONS**

The risk assessment conducted for the Arrowhead Plating site is a baseline assessment that addresses potential hazards to human health and the environment posed by contamination in the site study areas in the absence of any further remedial actions. The purpose of a baseline assessment is to provide information to aid in the determination of whether remedial actions should be undertaken.

The main components and results of the human health assessment are summarized below in Sections 7.7.1 through 7.7.3. The conclusions of the environmental assessment are summarized in Section 7.7.4.

### **7.7.1 Chemicals of Potential Concern**

Based on an evaluation of the RI sampling results, chemicals of potential concern (chemicals to be evaluated in the risk assessment) were identified. Chemicals of potential concern included several VOCs and a number of inorganic chemicals, and were identified in surface and subsurface soil, ground water, surface water, and sediment. Ground water contained the greatest number of chemicals of potential concern. As previously noted, this assessment did not include the additional 1991 data.

### **7.7.2 Human Exposure Pathways**

Potential human exposure pathways were selected for evaluation under both current and future land-use conditions. The exposure pathways which were evaluated quantitatively are:

TABLE 7-63  
COMPARISON OF SURFACE WATER CONCENTRATIONS WITH  
AMPHIBIAN CRITICAL TOXICITY VALUES

(Concentrations in ug/l)

Chemical	Exposure Point Concentration (ug/l) (a)	Amphibian Critical Toxicity Value
<b>Organics:</b>		
Bis(2-ethylhexyl)phthalate	ND (10-18)	NA
1,2-Dichloroethene (total)	ND (5)	NA
Tetrachloroethene	ND (5)	NA
Trichloroethene	ND (5)	NA
<b>Inorganics:</b>		
Aluminum	516	114
Calcium	4,630	NA
Copper	3.2	38
Cyanide	ND(10)	NA
Iron	3,160	NA
Potassium	3,030	NA
Sodium	9,420	NA

(a) Each concentration is the arithmetic mean of concentrations measured in ST-5, -6, and -7 during the 2 sampling rounds.

ND = Not detected. Detection limits in parentheses.  
NA = Not available.

- Ground water—ingestion by future residents;
- Air—inhalation of chemicals that volatilize from surface soil to ambient air by current workers and by future residents;
- Soil—incidental ingestion and dermal contact with chemicals in surface soil by future residents;
- Surface water and Sediment—dermal contact with chemicals in surface water and sediment by playing children.

Exposure scenarios for each of the potential exposure pathways shown above were developed, and concentrations of chemicals to which populations might be exposed (exposure point concentrations) were determined. No ambient air samples were collected as part of the RI sampling; therefore, for the inhalation pathways, air concentrations at the exposure points were estimated based on measured surface soil concentrations. For the other exposure pathways quantitatively evaluated, exposure point concentrations were assumed to be the concentrations detected during 1990 RI sampling of various media. In the absence of other information, concentrations in the exposure medium were assumed to remain constant over the duration of exposure.

### 7.7.3 Risk Characterization

The calculation of risk for the exposure pathways selected to be assessed quantitatively involves estimating intakes by potentially exposed populations based on the assumed exposure scenario. These intakes are then combined with reference doses (RfDs, defined as acceptable daily doses for noncarcinogens) or slope factors (for potential carcinogens) to derive estimates of noncarcinogenic hazard or excess lifetime cancer risks of the potentially exposed populations.

Based on recent EPA guidance on risk assessment (EPA 1989a), intakes were quantified by estimating the RME associated with the pathway of concern. The RME is intended to represent a possible upper bound exposure to a typical individual and is combined with upper bound toxicity criteria to estimate risks.

Based on the exposure and risk analyses presented in the previous sections, the conclusions of the quantitative risk assessment are as follows:

- Ground water—For potential future residents ingesting ground water from the Arrowhead Plating site, the lifetime upper bound excess cancer risk is  $8 \times 10^{-2}$ . This risk is attributable primarily to 1,1-dichloroethene, tetrachloroethene, and trichloroethene. This risk exceeds the target risk range of  $10^{-6}$  to  $10^{-4}$  at Superfund sites (EPA 1990b). The hazard index exceeds one due primarily to the liver toxicants 1,1-dichloroethene, tetrachloroethene, 1,1,1-trichloroethane, and trichloroethene.
- Air—For workers in the manufacturing building, the cancer risk is  $1 \times 10^{-7}$ . For future residents, the upper bound excess lifetime cancer risks range from  $4 \times 10^{-9}$  to  $1 \times 10^{-7}$ . The hazard indices for air exposures to both workers and future residents do not exceed one in any case.

- **Surface Soil**—For potential future residents exposed to chemicals in surface soil, the upper bound excess lifetime cancer risk from both incidental ingestion and dermal contact ranges from  $1 \times 10^{-9}$  to  $2 \times 10^{-7}$ . The hazard indices are all less than one.
- **Surface water and Sediment**—For children wading in surface water, the upper bound excess lifetime cancer risk associated with dermal contact with surface water and sediment is  $8 \times 10^{-9}$ . The hazard index is less than one.

#### 7.7.4 Environmental Assessment

The steps in an environmental assessment are similar to those for human health risk assessment. In this assessment, environmental receptors were first identified. Two species of special concern, the federal endangered bald eagle, and the state endangered eastern tiger salamander, were identified as potential receptors near the site. Indicator species or species groups were then selected based primarily on the potential for significant exposure. The potential for exposure of most terrestrial animals is considered minimal because the chemicals present at the Arrowhead Plating site show little potential to bioaccumulate. This is particularly important for top predators such as the endangered bald eagle. Two species or species groups with the highest potential for significant exposure are aquatic life as a group and the state endangered eastern tiger salamander. These were selected as indicator species at the Arrowhead Plating site.

Potential exposure pathways for the indicator species were evaluated to determine the likelihood of negative effects from site-related chemicals. Exposure pathways selected for quantification for aquatic life included direct contact with surface water and sediment. The state endangered eastern tiger salamander is terrestrial in adult form, but it deposits eggs into surface water where they hatch into aquatic larvae. These larvae are considered more sensitive than adults to chemicals in surface water. Therefore, the exposure pathways selected for quantification for the salamander were direct contact of the aquatic embryo-larval stage with surface water and sediment. Different exposure point concentrations were calculated for the salamander because potential breeding habitat exists only at ST5, 6, and 7.

Because AWQCs were exceeded for several inorganic chemicals, it is possible that aquatic life in surface water near the Arrowhead Plating site may experience negative impacts from the presence of these chemicals in surface water. Furthermore, based on concentrations relative to available amphibian toxicity values, it is possible that immature life stages of some amphibians could be adversely impacted by chemicals in surface water. The one available sediment toxicity value for amphibians (for bis[2-ethylhexyl]phthalate) was not exceeded by the exposure point concentration. Because the background concentrations for some of the inorganic chemicals also exceed toxicity values, adverse impacts to amphibians and aquatic life could be a more widespread problem.

#### 7.7.5 Summary of Findings Based on 1991 Data

From the review of the additional data, it was concluded that impacts on the risk assessment were as follows:

#### **Current Site Use.**

- From a human health risk perspective, no receptors exist. Therefore, the additional data do not have an impact on human health risks under current site use conditions;
- From an environmental risk perspective, the results of the risk assessment are not impacted further by the new tributary data because the presence of VOCs is limited in extent and does not persist in downstream locations;

#### **Future Site Use.**

- Estimated risks for surface and subsurface soils were not impacted by the additional data because (1) surface soil data were within the range of the detected concentrations used in the risk assessment, and (2) no significant pathway for exposure to subsurface soil was identified;
- The quantitative risk estimate for the ingestion of ground water was calculated herein to be fairly high. Inclusion of the additional data would increase this risk estimate. Given that the potential risks associated with the groundwater pathway were already found to be unacceptable, inclusion of the additional data from the quantitative analysis would not impact the overall result of the RI, namely, the need for groundwater remediation; and
- The additional data indicated the presence of VOCs in the surface water and sediments of the midfork and south fork tributaries of Scates Branch. Because these VOCs do not significantly persist downstream in these tributaries, adverse impacts on the estimated risks would be minimal.

In conclusion, although the additional data have some impact on the quantitative risk estimate (as indicated above and as further discussed in Appendix K), these data do not significantly impact the conclusions of the Baseline Risk Assessment presented in this section.

## 8. SUMMARY OF REMEDIAL INVESTIGATION

The RI at the Arrowhead Plating site has identified source areas, defined the nature and extent of contamination, assessed the rate and mechanisms of migration, and evaluated the potential threat to human health and the environment. As described in Section 3, the field investigation activities conducted to meet these objectives included completion of soil borings with soil sampling, installation and sampling of monitoring wells, surface soil sampling, surface water and sediment sampling, and aquifer testing. A summary of the hydrogeologic data was presented in Section 4 of this report, and analytical data were provided in Section 5. The overall assessment of contamination was described in Section 6, and Section 7 presented the risk assessment. Therefore, the purpose of this section is to briefly summarize the conclusions, describe the identified data limitations and suggested future work, and provide a preliminary discussion of remedial actions.

### 8.1 SUMMARY OF FINDINGS

Past site operations have resulted in VOC contamination in ground water as well as the limited presence of elevated concentrations of cyanide and selected inorganic compounds in soils and ground water beneath the Arrowhead site. Based on the available information, current activities at the facility and surrounding properties do not appear to be contributing to the observed contamination problems. With one possible exception (soils beneath the solvent tank, which presumably contain VOCs), ongoing contaminant sources were not identified during this RI. This situation is the result of the Immediate Removal Action, which appears to have been successful in removing the primary sources of contamination.

Based on the current land use, at and around the Arrowhead site, and the identified nature and extent of VOCs and inorganic compounds, no significant risks to human health or the environment were found to exist at this time. However, because the VOC contamination is expected to remain in the environment for several decades, the potential risks to human health could increase if land use changed in the future. For example, under a worst-case scenario, if a person were to use the contaminated shallow aquifer for drinking water for a long period of time, the increased cancer risk would be very high. Therefore, it appears that some type of remediation of VOCs in ground water is necessary.

### 8.2 DATA LIMITATIONS

Substantial amounts of data have been collected during this RI. The work included completion of all of the tasks proposed in the Work Plan, as well as additional off-site data collection at the request of VADWM and the U.S. EPA. The primary objectives of the RI have been achieved and sufficient data have been collected to complete the FS. However, additional information may be needed to complete the remedial design phase following the FS. The additional information that will be needed will depend on the selected remedial alternative. For example, in the event that a groundwater extraction and treatment system is part of the selected remedial alternative, more detailed knowledge of aquifer flow conditions will be needed. Such data would be gathered from a pump test at the site, and the information would be used to locate and design extraction wells.

### 8.3 OVERVIEW OF FEASIBILITY STUDY

The primary purpose of the forthcoming FS will be to fully develop and evaluate remedial alternatives for the Arrowhead Plating site using detailed criteria. Based on the data presented herein, the focus of the FS for the Arrowhead Plating site is expected to be the remediation of volatile organic compound contamination in ground water and the potentially contaminated soils beneath the solvent storage tank.

The FS process will be conducted in accordance with EPA guidance documents and as such will begin by specifying remedial action objectives and identifying general response actions. For each media, Applicable or Relevant and Appropriate Requirements (ARARs) will be identified. Applicable remedial technologies will then be identified and screened in order to develop remedial alternatives. Typically, these alternatives will consist of combinations of more than one response action and technology. The FS process will conclude with a detailed comparative analysis of the remedial alternatives.

**APPENDIX A**  
**REFERENCES**

**AR301548**

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# MONITORING WELL PURGING FORM

WELL NO. <u>MW9</u>	
WELL/SITE DESCRIPTION: <u>Arrowhead Planting</u>	
DATE: <u>2/5/91</u>	TIME: <u>2:45 PM</u> WEATHER AIR TEMP: _____

WELL DEPTH <u>31.58</u> FT (TOP OF PVC)	PVC STICK-UP HT. _____ FT
WATER DEPTH <u>19.22</u> FT (TOP OF PVC)	CASING HT. _____ FT
WATER COLUMN HEIGHT <u>12.36</u> FT	WELL DIAMETER _____ IN.
EQUIVALENT VOLUME OF STANDING WATER <u>1.98</u> (GAL) [V = $\pi r^2 h$ , 7.48 GAL = 1 cft]	SANDPACK DIAM. _____ IN.
VOLUME OF BAILER <u>0.27</u> (GAL) <input checked="" type="checkbox"/>	OR PUMP RATE _____ (GPM)
TOTAL NO. OF BAILERS (3-5 EQUIV.) <u>~30</u>	OR PUMP TIME _____ MIN.
WELL WENT DRY? (Y/N) <u>N</u> NO. OF BAILERS <u>40</u>	OR PUMP TIME _____ MIN.
VOL. REMOVED <u>10</u> (GAL)	RECOVERY TIME _____ MIN.
PURGE AGAIN? (Y/N) <u>N</u>	TOTAL VOL. REMOVED _____ (GAL)

	TIME	pH	TEMP (°F)	COND (UMHO/CM)
INITIAL T(0)	<u>2:57</u>	<u>4.95</u>	<u>63</u>	<u>130</u>
DURING	<u>3:02</u>	<u>4.64</u>	<u>63</u>	<u>170</u>
DURING	<u>3:05</u>	<u>4.60</u>	<u>63</u>	<u>180</u>
FINAL	<u>3:08</u>	<u>4.54</u>	<u>63</u>	<u>180</u>

CHK ANALYSIS	SAMPLE CONTAINER NO.	REMARKS (FILTERED/PRESERVED, ETC.)
✓ <u>VOA</u>	<u>40 ml glass vials 2</u>	<u>2 drops HCl preserved in field</u>
✓ <u>CN-</u>	<u>1-liter poly 1</u>	<u>NaOH by lab</u>
✓ <u>Total Metals</u>	<u>1</u>	<u>HNO<sub>3</sub> ✓</u>
✓ <u>Filtered</u>	<u>1</u>	<u>Filtered HNO<sub>3</sub> preserved</u>

TOTAL NUMBER OF CONTAINERS FOR SAMPLE 5

**DESCRIPTION OF SAMPLE CONDITIONS**

SAMPLE COLOR \_\_\_\_\_ ODOR \_\_\_\_\_ HNU READING \_\_\_\_\_

HIGH CONCENTRATIONS EXPECTED? \_\_\_\_\_ HIGH HAZARD? \_\_\_\_\_

UNUSUAL FEATURES \_\_\_\_\_

WEATHER/TEMPERATURE \_\_\_\_\_ SAMPLER \_\_\_\_\_

SIGNATURE \_\_\_\_\_

For 2" well .16(h) = Vol. in gallons  
 For 4" well .65(h) = Vol. in gallons

C-5

Bailers

length	diameter	Volume (gallons)
3'	1.5"	0.27
5'	1.5"	0.45
3'	3"	0.65

5. AR301645<sub>8</sub>

# MONITORING WELL PURGING FORM

WELL NO. <u>MW10</u>	
WELL/SITE DESCRIPTION: <u>Arroyo Plating</u>	
DATE: <u>2/5/91</u>	TIME: <u>3:30PM</u> WEATHER AIR TEMP: _____

WELL DEPTH <u>31.47</u> FT (TOP OF PVC)	PVC STICK-UP HT. _____ FT
WATER DEPTH <u>15.64</u> FT (TOP OF PVC)	CASING HT. _____ FT
WATER COLUMN HEIGHT <u>15.83</u> FT	WELL DIAMETER _____ IN.
EQUIVALENT VOLUME OF STANDING WATER <u>253</u> (GAL) [V = $\pi r^2 h$ , 7.48 GAL = 1 cft]	SANDPACK DIAM. _____ IN.
VOLUME OF BAILER <u>0.27</u> (GAL) <del>or</del> PUMP RATE _____ (GPM)	
TOTAL NO. OF BAILERS (3-5 EQUIV.) <u>~35</u> <del>or</del> PUMP TIME _____ MIN.	
WELL WENT DRY? (Y/N) <u>N</u> NO. OF BAILERS <u>~36</u> <del>or</del> PUMP TIME _____	
VOL. REMOVED <u>9</u> (GAL)	RECOVERY TIME _____ MIN.
PURGE AGAIN? (Y/N) <u>N</u>	TOTAL VOL. REMOVED _____ (GAL)

	TIME	pH	TEMP (°C/°F)	COND (UMHO/CM)
INITIAL T(0)	<u>3:39</u>	<u>6.64</u>	<u>61</u>	<u>off scale</u>
DURING	<u>3:42</u>	<u>4.73</u>	<u>61</u>	<u>off-scale</u>
DURING	<u>3:45</u>	<u>4.67</u>	<u>61</u>	<u>off-scale</u>
FINAL	<u>3:47</u> <u>2:52</u>	<u>4.63</u> <u>4.58</u>	<u>61</u> <u>61</u>	<u>off-scale</u> <u>off-scale</u>

CHK ANALYSIS	SAMPLE CONTAINER NO.	REMARKS (FILTERED/PRESERVED, ETC.)
✓ <u>VOA</u>	<u>40ml glass vial</u>	<u>2</u> <u>2 drops HCl preserved in field</u>
✓ <u>CN<sup>-</sup></u>	<u>1-liter poly</u>	<u>1</u> <u>NaOH by lab</u>
✓ <u>Total Metals</u>	<u>1</u>	<u>1</u> <u>4 NO<sub>3</sub></u>
✓ <u>Filtered</u>	<u>1</u>	<u>1</u> <u>HNO<sub>3</sub> (filtered)</u>

TOTAL NUMBER OF CONTAINERS FOR SAMPLE 5

**DESCRIPTION OF SAMPLE CONDITIONS**

SAMPLE COLOR \_\_\_\_\_ ODOR \_\_\_\_\_ HNU READING \_\_\_\_\_

HIGH CONCENTRATIONS EXPECTED? \_\_\_\_\_ HIGH HAZARD? \_\_\_\_\_

UNUSUAL FEATURES \_\_\_\_\_

WEATHER/TEMPERATURE \_\_\_\_\_ SAMPLER \_\_\_\_\_

SIGNATURE \_\_\_\_\_

For 2" well .16(h) = Volume in gallons  
 For 4" well .65(h) = Vol. in gallons

C-5

length	diameter	Volume (gallons)
3'	1.5"	0.27
5'	1.5"	0.45

Bailers  
 3' AR301646

# MONITORING WELL PURGING FORM

WELL NO. <u>MW11</u>	
WELL/SITE DESCRIPTION: <u>Armstrong Planting</u>	
DATE: <u>2/6/91</u>	TIME: <u>10:10</u> WEATHER AIR TEMP: _____

WELL DEPTH <u>27.4</u> FT (TOP OF PVC)	PVC STICK-UP HT. _____ FT
WATER DEPTH <u>11.74</u> FT (TOP OF PVC)	CASING HT. _____ FT
WATER COLUMN HEIGHT <u>15.66</u> FT	WELL DIAMETER _____ IN.
EQUIVALENT VOLUME OF STANDING WATER <u>2.50</u> (GAL) [V = $\pi r^2 h$ , 7.48 GAL = 1 cft]	SANDPACK DIAM. _____ IN.
VOLUME OF BAILER <u>0.27</u> (GAL) <u>or</u> PUMP RATE _____ (GPM)	
TOTAL NO. OF BAILERS (3-5 EQUIV.) <u>~30</u> <u>or</u> PUMP TIME _____ MIN.	
WELL WENT DRY? (Y/N) <u>N</u> NO. OF BAILERS <u>40</u> <u>or</u> PUMP TIME _____	
VOL. REMOVED <u>10</u> (GAL) RECOVERY TIME _____ MIN.	
PURGE AGAIN? (Y/N) <u>N</u> TOTAL VOL. REMOVED _____ (GAL)	

	TIME	pH	TEMP (°F)	COND (UMHO/CM)
INITIAL T(0)	<u>10:15</u>	<u>5.24</u>	<u>57</u>	<u>540</u>
DURING	<u>10:18</u>	<u>5.15</u>	<u>57</u>	<u>800</u>
DURING	<u>10:22</u>	<u>5.12</u>	<u>57</u>	<u>830</u>
FINAL	<u>10:26</u>	<u>5.16</u>	<u>57</u>	<u>830</u>

CHK ANALYSIS	SAMPLE CONTAINER NO.	REMARKS (FILTERED/PRESERVED, ETC.)
✓ VOA	<u>40ml glass vials 2</u>	<u>2 drops conc. HCl preserved in field</u>
✓ $Ca^{2+}$	<u>1-liter poly 1</u>	<u>NaOH preserved by lab</u>
✓ Total Metals	<u>1</u>	<u>HNO<sub>3</sub></u>
✓ Filtered	<u>1</u>	<u>filtered</u>

TOTAL NUMBER OF CONTAINERS FOR SAMPLE 5

**DESCRIPTION OF SAMPLE CONDITIONS**

SAMPLE COLOR \_\_\_\_\_ ODOR \_\_\_\_\_ HNU READING \_\_\_\_\_

HIGH CONCENTRATIONS EXPECTED? \_\_\_\_\_ HIGH HAZARD? \_\_\_\_\_

UNUSUAL FEATURES \_\_\_\_\_

WEATHER/TEMPERATURE \_\_\_\_\_ SAMPLER \_\_\_\_\_

SIGNATURE \_\_\_\_\_

For 2" well .16(h) = Vol. in gallons  
 For 4" well .65(h) = Vol. in gallons  
 C-5

Bailers

length	diameter	volume (gallons)
3'	1.5"	0.27
5'	1.5"	0.45
3'	3"	AR301647
5'	3"	

# MONITORING WELL PURGING FORM

WELL NO. <u>MW12</u>	
WELL/SITE DESCRIPTION: <u>Ammonia Plant</u>	
DATE: <u>2/6/91</u>	TIME: <u>9:38</u> WEATHER AIR TEMP: _____

WELL DEPTH <u>21.91</u> FT (TOP OF PVC)	PVC STICK-UP HT. _____ FT
WATER DEPTH <u>7.15</u> FT (TOP OF PVC)	CASING HT. _____ FT
WATER COLUMN HEIGHT <u>14.76</u> FT	WELL DIAMETER _____ IN.
EQUIVALENT VOLUME OF STANDING WATER <u>2.36</u> (GAL) [V = $\pi r^2 h$ , 7.48 GAL = 1 cft]	SANDPACK DIAM. _____ IN.
VOLUME OF BAILER <u>0.27</u> (GAL) <u>or</u> PUMP RATE _____ (GPM)	
TOTAL NO. OF BAILERS (3-5 EQUIV.) <u>~30</u> <u>or</u> PUMP TIME _____ MIN.	
WELL WENT DRY? (Y/N) <u>N</u> NO. OF BAILERS <u>38</u> <u>or</u> PUMP TIME _____	
VOL. REMOVED <u>9.5</u> (GAL)	RECOVERY TIME _____ MIN.
PURGE AGAIN? (Y/N) <u>N</u>	TOTAL VOL. REMOVED _____ (GAL)

	TIME	pH	TEMP ( <del>°C</del> °F)	COND (UMHO/CM)
INITIAL T(0)	<u>9:45</u>	<u>5.29</u>	<u>56</u>	<u>1130</u>
DURING	<u>9:47</u>	<u>5.17</u>	<u>56</u>	<u>1200</u>
DURING	<u>9:50</u>	<u>5.17</u>	<u>56</u>	<u>1080</u>
FINAL	<u>9:53</u> <u>9:56</u>	<u>5.17</u> <u>5.17</u>	<u>56</u> <u>56</u>	<u>1070</u> <u>1060</u>

CHK ANALYSIS	SAMPLE CONTAINER NO.	REMARKS (FILTERED/PRESERVED, ETC.)
✓ VOA	40 ml glass vials 2	2 drops HCl preserved in field
✓ CN <sup>-</sup>	1-liter poly 1	NaOH by lab
✓ Total Metals	1	HNO <sub>3</sub>
✓ Filtered	1	↓ ↓ ↓ ↓; filtered

TOTAL NUMBER OF CONTAINERS FOR SAMPLE 5

**DESCRIPTION OF SAMPLE CONDITIONS**

SAMPLE COLOR \_\_\_\_\_ ODOR \_\_\_\_\_ HNU READING \_\_\_\_\_

HIGH CONCENTRATIONS EXPECTED? \_\_\_\_\_ HIGH HAZARD? \_\_\_\_\_

UNUSUAL FEATURES \_\_\_\_\_

WEATHER/TEMPERATURE \_\_\_\_\_ SAMPLER \_\_\_\_\_

SIGNATURE \_\_\_\_\_

For 2" well .16(h) = Vol in gallons  
 For 4" well .65(h) = Vol in gallons

C-5

Bailers

length	diameter	Volume (g)
3'	1.5"	0.27
5'	1.5"	0.45
3'	3"	1.1

AR301648

# MONITORING WELL PURGING FORM

WELL NO. MW13  
 WELL/SITE DESCRIPTION: Arrowhead Platting  
 DATE: 2/6/91 TIME: 8:10am WEATHER AIR TEMP: \_\_\_\_\_

WELL DEPTH 16.10 FT (TOP OF PVC) PVC STICK-UP HT. \_\_\_\_\_ FT  
 CASING HT. \_\_\_\_\_ FT  
 WATER DEPTH 3.86 FT (TOP OF PVC) WELL DIAMETER \_\_\_\_\_ IN.  
 WATER COLUMN HEIGHT 12.24 FT SANDPACK DIAM. \_\_\_\_\_ IN.  
 EQUIVALENT VOLUME OF STANDING WATER 1.96 (GAL) [ $V = \pi r^2 h$ , 7.48 GAL = 1 cft]  
 VOLUME OF BAILER 0.27 (GAL) 4 OR PUMP RATE \_\_\_\_\_ (GPM)  
 TOTAL NO. OF BAILERS (3-5 EQUIV.) ~25 OR PUMP TIME \_\_\_\_\_ MIN.  
 WELL WENT DRY? (Y/N) N NO. OF BAILERS 60 OR PUMP TIME \_\_\_\_\_  
 VOL. REMOVED 15 (GAL) RECOVERY TIME \_\_\_\_\_ MIN.  
 PURGE AGAIN? (Y/N) N TOTAL VOL. REMOVED \_\_\_\_\_ (GAL)

	TIME	pH	TEMP <del>(°F)</del>	COND (UMHO/CM)
INITIAL T(0)	<u>8:12</u>	<u>4.27</u>	<u>50</u>	<u>1520</u>
DURING	<u>8:17</u>	<u>4.41</u>	<u>49</u>	<u>1300</u>
DURING	<u>8:22</u>	<u>4.52</u>	<u>49</u>	<u>1300</u>
<del>DURING</del>	<u>8:27</u>	<u>4.47</u>	<u>50</u>	<u>1280</u>
FINAL	<u>8:30</u>	<u>4.43</u>	<u>50</u>	<u>1280</u>

CHK ANALYSIS	SAMPLE CONTAINER NO.	REMARKS (FILTERED/PRESERVED, ETC.)
<u>✓ VOA</u>	<u>40ml glass vial</u>	<u>2</u>
<u>✓ CN<sup>-</sup></u>	<u>1-liter poly</u>	<u>1</u>
<u>✓ Total Metals</u>	<u>1</u>	<u>1</u>
<u>✓ Filtered</u>	<u>1</u>	<u>1</u>
		<u>2 drops HCl preserved in field</u>
		<u>NaOH by kb</u>
		<u>HNO<sub>3</sub></u>
		<u>↓ ↓ ↓ (filtered)</u>

TOTAL NUMBER OF CONTAINERS FOR SAMPLE 5

DESCRIPTION OF SAMPLE CONDITIONS

SAMPLE COLOR \_\_\_\_\_ ODOR \_\_\_\_\_ HNU READING \_\_\_\_\_  
 HIGH CONCENTRATIONS EXPECTED? \_\_\_\_\_ HIGH HAZARD? \_\_\_\_\_  
 UNUSUAL FEATURES \_\_\_\_\_  
 WEATHER/TEMPERATURE \_\_\_\_\_ SAMPLER \_\_\_\_\_

SIGNATURE \_\_\_\_\_

For 2" well .16(h) = Volume in gallons  
 For 4" well .65(h) = Vol. in gallons

C-5

length	diameter	Volume (gallons)
3'	1.5"	0.27
5'	1.5"	0.45
3'		
5'		

AR301649

# MONITORING WELL PURGING FORM

WELL NO. <u>MW 21</u>	
WELL/SITE DESCRIPTION: <u>middle of old pond</u>	
DATE: <u>2/21/91</u>	TIME: <u>11:15</u> WEATHER AIR TEMP: <u>75°</u>
WELL DEPTH <u>36.7</u> FT (TOP OF PVC)	PVC STICK-UP HT. <u>1.9</u> FT
WATER DEPTH <u>18.3</u> FT (TOP OF PVC)	CASING HT. <u>1.9</u> FT
WATER COLUMN HEIGHT <u>18.4</u> FT	WELL DIAMETER <u>2</u> IN.
EQUIVALENT VOLUME OF STANDING WATER <u>2.9</u> (GAL) [V = $\pi r^2 h$ , 7.48 GAL = 1 cft]	SANDPACK DIAM. <u>4</u> IN.
VOLUME OF BAILER <u>1/4</u> (GAL) <u>4</u> OR PUMP RATE _____ (GPM)	
TOTAL NO. OF BAILERS (3-5 EQUIV.) <u>42</u> OR PUMP TIME _____ MIN.	
WELL WENT DRY? (Y/N) <u>N</u> NO. OF BAILERS _____ OR PUMP TIME _____	
VOL. REMOVED <u>10.50</u> (GAL)	RECOVERY TIME _____ MIN.
PURGE AGAIN? (Y/N) _____	TOTAL VOL. REMOVED <u>10.50</u> (GAL)

	TIME	pH	TEMP (C)	COND (UMHO/CM)
INITIAL T(0)	<u>11:22</u>	<u>5.05</u>	<u>57.0</u>	<u>1837</u>
DURING	<u>11:27</u>	<u>4.22</u>	<u>57.6</u>	<u>1998</u>
DURING	<u>11:31</u>	<u>4.21</u>	<u>56.8</u>	<u>2110</u>
FINAL	<u>11:36</u>	<u>4.12</u>	<u>56.2</u>	<u>2150</u>

CHK ANALYSIS	SAMPLE CONTAINER NO.	REMARKS (FILTERED/PRESERVED, ETC.)
<input checked="" type="checkbox"/> VOC	<u>40 ml glass</u> <u>2</u>	<u>HCl</u>
<input checked="" type="checkbox"/> CN	<u>1-liter poly</u> <u>1</u>	<u>N.O.H</u>
<input checked="" type="checkbox"/> TOTAL METALS	<u>1-liter poly</u> <u>1</u>	<u>HNO<sub>3</sub></u>
<input checked="" type="checkbox"/> DISSOLVED METALS	<u>1-liter poly</u> <u>1</u>	<u>HNO<sub>3</sub>; filtered</u>

TOTAL NUMBER OF CONTAINERS FOR SAMPLE 5

**DESCRIPTION OF SAMPLE CONDITIONS**

SAMPLE COLOR orange ODOR none HNU READING 0.0ppm

HIGH CONCENTRATIONS EXPECTED? NO HIGH HAZARD? NO

UNUSUAL FEATURES NONE

WEATHER/TEMPERATURE 45°; partly cloudy SAMPLER MR/JSW

SIGNATURE Jal Whaley

For 2" well .16(h) = Vol. in gallons	18.4		Bailers		
For 4" well .65(h) = Vol. in gallons	.16	3'	1.5"	0.27	
	C-5 1104	5'	1.5"	0.45	
	184			1.1	
	AR301650			1.8	

# MONITORING WELL PURGING FORM

WELL NO. <u>MW22</u>	
WELL/SITE DESCRIPTION: <u>between building and road</u>	
DATE: <u>2/21/91</u>	TIME: <u>12:05</u> WEATHER AIR TEMP: <u>50°</u>

WELL DEPTH <u>27.2</u> FT (TOP OF PVC)	PVC STICK-UP HT. <u>2.0'</u> FT
WATER DEPTH <u>19.2</u> FT (TOP OF PVC)	CASING HT. <u>2.7'</u> FT
WATER COLUMN HEIGHT <u>8.0</u> FT	WELL DIAMETER <u>2</u> IN.
EQUIVALENT VOLUME OF STANDING WATER <u>1.3</u> (GAL) [V = $\pi r^2 h$ , 7.48 GAL = 1 cft]	SANDPACK DIAM. <u>4</u> IN.
VOLUME OF BAILER <u>4</u> (GAL) <input checked="" type="checkbox"/> OK PUMP RATE _____ (GPM)	
TOTAL NO. OF BAILERS (3-5 EQUIV.) <u>18</u> <input checked="" type="checkbox"/> OK PUMP TIME _____ MIN.	
WELL WENT DRY? (Y/N) <u>N</u> NO. OF BAILERS _____ <input checked="" type="checkbox"/> OK PUMP TIME _____	
VOL. REMOVED <u>4.5</u> (GAL)	RECOVERY TIME _____ MIN.
PURGE AGAIN? (Y/N) _____	TOTAL VOL. REMOVED <u>4.5</u> (GAL)

	TIME	pH	TEMP (C)	COND (UMHO/CM)
INITIAL T(0)	<u>12:09</u>	<u>4.88</u>	<u>55.8</u>	<u>80</u>
DURING	<u>12:12</u>	<u>4.89</u>	<u>55.6</u>	<u>82</u>
DURING	<u>12:14</u>	<u>4.89</u>	<u>56.3</u>	<u>83</u>
FINAL	<u>12:15</u>	<u>4.89</u>	<u>56.1</u>	<u>83</u>

CHK ANALYSIS	SAMPLE CONTAINER NO.	REMARKS (FILTERED/PRESERVED, ETC.)
<input checked="" type="checkbox"/> VOC	40 ml glass 2	HCl
<input checked="" type="checkbox"/> CN	1-liter poly 1	NaOH
<input checked="" type="checkbox"/> TOTAL METALS	1-liter poly 1	HNO <sub>3</sub>
<input checked="" type="checkbox"/> DISSOLVED METALS	1-liter poly 1	HNO <sub>3</sub> , filtered

TOTAL NUMBER OF CONTAINERS FOR SAMPLE 5

DESCRIPTION OF SAMPLE CONDITIONS			
SAMPLE COLOR <u>orange</u>	ODOR <u>none</u>	HNU READING <u>2.0 ppm</u>	
HIGH CONCENTRATIONS EXPECTED? <u>NO</u>	HIGH HAZARD? <u>NO</u>		
UNUSUAL FEATURES <u>NONE</u>			
WEATHER/TEMPERATURE <u>50°, cloudy</u>	SAMPLER <u>MR; JFW</u>		

SIGNATURE <u>Jol Whelpley</u>
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For 2" well .16(h) = Vol. in gallons .16  
 For 4" well .65(h) = Vol. in gallons .128  
 C-5

Length	Diameter	Volume (gallons)
3'	1.5"	0.27
5'	1.5"	0.45
3'	2"	0.16
5'		

AR301651

# MONITORING WELL PURGING FORM

WELL NO. <u>MW23</u>	
WELL/SITE DESCRIPTION: <u>farmer's field east of site</u>	
DATE: <u>2/21/91</u>	TIME: <u>8:30</u> WEATHER AIR TEMP: <u>50°</u>

WELL DEPTH <u>34.3</u> FT (TOP OF PVC)	PVC STICK-UP HT. <u>1.6</u> FT
WATER DEPTH <u>21.3</u> FT (TOP OF PVC)	CASING HT. <u>26</u> FT
WATER COLUMN HEIGHT <u>13.0</u> FT	WELL DIAMETER <u>2</u> IN.
EQUIVALENT VOLUME OF STANDING WATER <u>2.1</u> (GAL) [V = $\pi r^2 h$ , 7.48 GAL = 1 cft]	SANDPACK DIAM. <u>4</u> IN.
VOLUME OF BAILER <u>1/4</u> (GAL) <input checked="" type="checkbox"/> PUMP RATE _____ (GPM)	
TOTAL NO. OF BAILERS (3-5 EQUIV.) <u>30</u> <input checked="" type="checkbox"/> PUMP TIME _____ MIN.	
WELL WENT DRY? (Y/N) <u>N</u> NO. OF BAILERS _____ <input checked="" type="checkbox"/> PUMP TIME _____	
VOL. REMOVED <u>7.5</u> (GAL)	RECOVERY TIME _____ MIN.
PURGE AGAIN? (Y/N) _____	TOTAL VOL. REMOVED <u>75</u> (GAL)

	TIME	pH	TEMP (°F)	COND (UMHO/CM)
INITIAL T(0)	<u>8:54</u>	<u>6.28</u>	<u>53.1</u>	<u>1480</u>
DURING	<u>8:56</u>	<u>6.08</u>	<u>55.1</u>	<u>1710</u>
DURING	<u>9:02</u>	<u>5.35</u>	<u>55.2</u>	<u>1910</u>
FINAL	<u>9:04</u> <u>9:05</u>	<u>5.25</u> <u>5.24</u>	<u>55.8</u> <u>55.9</u>	<u>1960</u> <u>1980</u>

CHK ANALYSIS	SAMPLE CONTAINER NO.	REMARKS (FILTERED/PRESERVED, ETC.)
<input checked="" type="checkbox"/> VOC	<u>40ml glass</u> <u>2</u>	<u>HCl</u>
<input checked="" type="checkbox"/> CN	<u>1-liter poly</u> <u>1</u>	<u>NaOH</u>
<input checked="" type="checkbox"/> TOTAL METALS	<u>1-liter poly</u> <u>1</u>	<u>HNO<sub>3</sub></u>
<input checked="" type="checkbox"/> DISSOLVED METALS	<u>1-liter poly</u> <u>1</u>	<u>HNO<sub>3</sub>; filtered</u>

TOTAL NUMBER OF CONTAINERS FOR SAMPLE 5

**DESCRIPTION OF SAMPLE CONDITIONS**

SAMPLE COLOR orange ODOR none HNU READING 0.0 ppm

HIGH CONCENTRATIONS EXPECTED? NO HIGH HAZARD? NO

UNUSUAL FEATURES NONE

WEATHER/TEMPERATURE 50°, sunny SAMPLER MR / JFW

SIGNATURE John Whelpley

For 2" well .16(h) = Volume in gallons 13.0

For 4" well .65(h) = Vol. in gallons 16

AR301652

C-5 280  
2086

Length	Diameter	Volume (gallons)
3'	1.5"	0.27
5'	1.5"	0.45

# MONITORING WELL PURGING FORM

WELL NO. <u>MW 24</u>	
WELL/SITE DESCRIPTION: <u>Barner's field East of site</u>	
DATE: <u>2/21/91</u>	TIME: <u>9:25</u> WEATHER AIR TEMP: <u>45°</u>
WELL DEPTH <u>33.8</u> FT (TOP OF PVC)	PVC STICK-UP HT. <u>1.5</u> FT
WATER DEPTH <u>18.0</u> FT (TOP OF PVC)	CASING HT. _____ FT
WATER COLUMN HEIGHT <u>15.8</u> FT	WELL DIAMETER <u>2</u> IN.
EQUIVALENT VOLUME OF STANDING WATER <u>2.5</u> (GAL) [V = $\pi r^2 h$ , 7.48 GAL = 1 cft]	SANDPACK DIAM. <u>4</u> IN.
VOLUME OF BAILER <u>1/4</u> (GAL) <input checked="" type="checkbox"/> OK PUMP RATE _____ (GPM)	
TOTAL NO. OF BAILERS (3-5 EQUIV.) <u>35</u> <input checked="" type="checkbox"/> OK PUMP TIME _____ MIN.	
WELL WENT DRY? (Y/N) <u>N</u> NO. OF BAILERS _____ <input checked="" type="checkbox"/> OK PUMP TIME _____	
VOL. REMOVED <u>8.75</u> (GAL)	RECOVERY TIME _____ MIN.
PURGE AGAIN? (Y/N) _____	TOTAL VOL. REMOVED <u>8.75</u> (GAL)

	TIME	pH	TEMP (°F)	COND (UMHO/CM)
INITIAL T(0)	<u>9:30</u>	<u>5.95</u>	<u>54.1</u>	<u>1003</u>
DURING	<u>9:35</u>	<u>5.38</u>	<u>55.1</u>	<u>1327</u>
DURING	<u>9:37</u>	<u>5.40</u>	<u>54.6</u>	<u>1347</u>
FINAL	<u>9:41</u>	<u>5.20</u>	<u>54.7</u>	<u>1410</u>
	<u>9:42</u>	<u>5.26</u>	<u>55.2</u>	<u>1458</u>
	<u>9:43</u>	<u>5.32</u>	<u>55.4</u>	<u>1585</u>
	<u>9:44</u>	<u>5.34</u>	<u>55.4</u>	<u>1680</u>

CHK ANALYSIS	SAMPLE CONTAINER NO.	REMARKS (FILTERED/PRESERVED, ETC.)
<input checked="" type="checkbox"/> VOC	<u>40 ml glass</u> <u>3</u>	<u>HCL</u>
<input checked="" type="checkbox"/> CN	<u>1-liter poly</u> <u>1</u>	<u>NaOH</u>
<input checked="" type="checkbox"/> TOTAL METALS	<u>1-liter poly</u> <u>1</u>	<u>HNO<sub>3</sub></u>
<input checked="" type="checkbox"/> DISSOLVED METALS	<u>1-liter poly</u> <u>1</u>	<u>HNO<sub>3</sub>; filtered</u>

TOTAL NUMBER OF CONTAINERS FOR SAMPLE 5

DESCRIPTION OF SAMPLE CONDITIONS		
SAMPLE COLOR <u>Orange</u>	ODOR <u>none</u>	HNU READING <u>0.0 ppm</u>
HIGH CONCENTRATIONS EXPECTED? <u>NO</u>	HIGH HAZARD? <u>NO</u>	
UNUSUAL FEATURES <u>NONE</u>		
WEATHER/TEMPERATURE <u>45°, partly cloudy</u>		SAMPLER <u>MR/SFW</u>

SIGNATURE John Whelpley

For 2" well .16(h) = Vol. in gallons 15.8  
 For 4" well .65(h) = Vol. in gallons 16  
 948  
 C-5 158 x  
 2528

AR301653

length	diameter	Volume (gallons)
3'	1.5"	0.27
5'	1.5"	0.45
3'		
5'		

# MONITORING WELL PURGING FORM

WELL NO. <u>MW25</u>	
WELL/SITE DESCRIPTION: <u>farmer's field East of site</u>	
DATE: <u>2/21/91</u>	TIME: <u>10:10</u> WEATHER AIR TEMP: <u>45°</u>

WELL DEPTH <u>37.0</u> FT (TOP OF PVC)	PVC STICK-UP HT. <u>2.4</u> FT
	CASING HT. <u>2.5</u> FT
WATER DEPTH <u>22.8</u> FT (TOP OF PVC)	WELL DIAMETER <u>2</u> IN.
WATER COLUMN HEIGHT <u>14.2</u> FT	SANDPACK DIAM. <u>4</u> IN.
EQUIVALENT VOLUME OF STANDING WATER <u>2.3</u> (GAL) [V = $\pi r^2 h$ , 7.48 GAL = 1 cft]	
VOLUME OF BAILER <u>1/4</u> (GAL) <del>1</del>	OR PUMP RATE _____ (GPM)
TOTAL NO. OF BAILERS (3-5 EQUIV.) <u>33</u>	OR PUMP TIME _____ MIN.
WELL WENT DRY? (Y/N) <u>N</u> NO. OF BAILERS _____	OR PUMP TIME _____
VOL. REMOVED <u>8.25</u> (GAL)	RECOVERY TIME _____ MIN.
PURGE AGAIN? (Y/N) _____	TOTAL VOL. REMOVED <u>8.25</u> (GAL)

	TIME	pH	TEMP (°F)	COND (UMHO/CM)
INITIAL T(O)	<u>10:11</u>	<u>4.84</u>	<u>55.2</u>	<u>263</u>
DURING	<u>10:15</u>	<u>4.71</u>	<u>55.4</u>	<u>187</u>
DURING	<u>10:17</u>	<u>4.72</u>	<u>55.7</u>	<u>183</u>
FINAL	<u>10:20</u>	<u>4.69</u>	<u>56.2</u>	<u>184</u>

CHK ANALYSIS	SAMPLE CONTAINER NO.	REMARKS (FILTERED/PRESERVED, ETC.)
<u>✓</u> VOC	<u>40ml glass 2</u>	<u>HCl</u>
<u>✓</u> CN	<u>1-liter poly 1</u>	<u>NaOH</u>
<u>✓</u> T. METALS	<u>1-liter poly 1</u>	<u>HNO<sub>3</sub></u>
<u>✓</u> D. METALS	<u>1-liter poly 1</u>	<u>HNO<sub>3</sub> filtered</u>

TOTAL NUMBER OF CONTAINERS FOR SAMPLE 5

**DESCRIPTION OF SAMPLE CONDITIONS**

SAMPLE COLOR Orange ODOR none HNU READING 0.0ppm

HIGH CONCENTRATIONS EXPECTED? NO HIGH HAZARD? NO

UNUSUAL FEATURES NONE

WEATHER/TEMPERATURE 45°; partly cloudy SAMPLER MR. JFW

SIGNATURE John Whedepsky

→ For 2" well .16(h) = Vol. in gallons      14.2

For 4" well .65(h) = Vol. in gallons      .16

C-5      852

142 x

2277

length	diameter	Volume (gallons)
3'	1.5"	0.27
5'	1.5"	0.45
3'		

AR301654

# MONITORING WELL PURGING FORM

WELL NO. MW26  
 WELL/SITE DESCRIPTION: farmer's field east of facility  
 DATE: 2/21/91 TIME: 8:00 WEATHER AIR TEMP: 40°

WELL DEPTH 38.9 FT (TOP OF PVC) PVC STICK-UP HT. 2.3 FT  
 CASING HT. 23 FT  
 WATER DEPTH 240 FT (TOP OF PVC) WELL DIAMETER 2 IN.  
 WATER COLUMN HEIGHT 14.9 FT SANDPACK DIAM. 4 IN.  
 EQUIVALENT VOLUME OF STANDING WATER 2.4 (GAL) [ $V = \pi r^2 h$ , 7.48 GAL = 1 cft]  
 VOLUME OF BAILER 1/4 (GAL) 36 or PUMP RATE \_\_\_\_\_ (GPM)  
 TOTAL NO. OF BAILERS (3-5 EQUIV.) \_\_\_\_\_ or PUMP TIME \_\_\_\_\_ MIN.  
 WELL WENT DRY? (Y/N) N NO. OF BAILERS \_\_\_\_\_ or PUMP TIME \_\_\_\_\_  
 VOL. REMOVED 9 (GAL) RECOVERY TIME \_\_\_\_\_ MIN.  
 PURGE AGAIN? (Y/N) \_\_\_\_\_ TOTAL VOL. REMOVED 9.0 (GAL)

	<u>Vol</u>	<u>TIME</u>	<u>pH</u>	<u>TEMP (°F)</u>	<u>COND (UMHO/CM)</u>	
INITIAL T(0).	<u>5</u>	<u>8:12</u>	<u>4.95</u>	<u>47.5</u>	<u>260</u>	<u>Curdy</u>
DURING		<u>8:17</u>	<u>5.08</u>	<u>51.7</u>	<u>395</u>	
DURING		<u>8:24</u>	<u>5.16</u>	<u>52.9</u>	<u>422</u>	
FINAL		<u>8:25</u>	<u>5.23</u>	<u>52.9</u>	<u>437</u>	
		<u>8:26</u>	<u>5.24</u>	<u>52.9</u>	<u>738</u>	

<u>CHK ANALYSIS</u>	<u>SAMPLE CONTAINER NO.</u>	<u>REMARKS (FILTERED/PRESERVED, ETC.)</u>
<u>✓ VOC</u>	<u>40ml glass 2</u>	<u>2 drops HCl</u>
<u>✓ CN</u>	<u>1-liter poly 1</u>	<u>NaOH</u>
<u>✓ TOTAL METALS</u>	<u>1-liter poly 1</u>	<u>HNO<sub>3</sub></u>
<u>✓ DISSOLVED METALS</u>	<u>1-liter poly 1</u>	<u>HNO<sub>3</sub>; filtered</u>

TOTAL NUMBER OF CONTAINERS FOR SAMPLE 5

## DESCRIPTION OF SAMPLE CONDITIONS

SAMPLE COLOR Orange ODOR none HNU READING 0.0ppm  
 HIGH CONCENTRATIONS EXPECTED? NO HIGH HAZARD? NO  
 UNUSUAL FEATURES none  
 WEATHER/TEMPERATURE 40°, sunny SAMPLER MR/JFW

SIGNATURE Joh Whelpley

For 2" well .16(h) = Vol. in gallons 14.9  
 For 4" well .65(h) = Vol. in gallons x .16  
 0.5 894  
 149  
 2011

<u>length</u>	<u>diameter</u>	<u>Volume (gallons)</u>
3'	1.5"	0.27
5'	1.5"	0.45
3'	3"	1.1
5'		AR301655

# MONITORING WELL PURGING FORM

WELL NO. AR1

WELL/SITE DESCRIPTION: Arrowhead Plant

DATE: 2/6/91 TIME: 8:59 WEATHER AIR TEMP: \_\_\_\_\_

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WELL DEPTH 26.73 <sup>18.84</sup> <sup>8.50</sup> FT (TOP OF PVC) PVC STICK-UP HT. \_\_\_\_\_ FT

CASING HT. \_\_\_\_\_ FT

WATER DEPTH 26.50 <sup>10.34</sup> FT (TOP OF PVC) WELL DIAMETER \_\_\_\_\_ IN.

WATER COLUMN HEIGHT 6.23 <sup>1.65</sup> FT SANDPACK DIAM. \_\_\_\_\_ IN.

EQUIVALENT VOLUME OF STANDING WATER 100 (GAL) [V =  $\pi r^2 h$ , 7.48 GAL = 1 cft]

VOLUME OF BAILER 0.27 (GAL) <sup>~20</sup> or PUMP RATE \_\_\_\_\_ (GPM)

TOTAL NO. OF BAILERS (3-5 EQUIV.) 45 <sup>MS</sup> or PUMP TIME \_\_\_\_\_ MIN.

WELL WENT DRY? (Y/N) N NO. OF BAILERS 40 or PUMP TIME \_\_\_\_\_

VOL. REMOVED 10 (GAL) RECOVERY TIME \_\_\_\_\_ MIN.

PURGE AGAIN? (Y/N) N TOTAL VOL. REMOVED \_\_\_\_\_ (GAL)

---

	TIME	pH	TEMP (°F)	COND (UMHO/CM)
INITIAL T(0)	<u>9:07</u>	<u>4.61</u>	<u>57</u>	<u>250</u>
DURING	<u>9:10</u>	<u>4.58</u>	<u>57</u>	<u>250</u>
DURING	<u>9:14</u>	<u>4.60</u>	<u>57</u>	<u>230</u>
FINAL	<u>9:17</u>	<u>4.62</u>	<u>57</u>	<u>230</u>

---

CHK ANALYSIS	SAMPLE CONTAINER NO.	REMARKS (FILTERED/PRESERVED, ETC.)
✓ VOA	40 ml glass vials 2	2 drops HCl preserved in field
✓ CN <sup>-</sup>	1-liter poly 1	NaOH by kb
✓ Total Metals	1 1	HNO <sub>3</sub>
✓ Filtered	1 1	✓ ✓ ✓ (Filtered)

TOTAL NUMBER OF CONTAINERS FOR SAMPLE 5

---

**DESCRIPTION OF SAMPLE CONDITIONS**

SAMPLE COLOR \_\_\_\_\_ ODOR \_\_\_\_\_ HNU READING \_\_\_\_\_

HIGH CONCENTRATIONS EXPECTED? \_\_\_\_\_ HIGH HAZARD? \_\_\_\_\_

UNUSUAL FEATURES \_\_\_\_\_

WEATHER/TEMPERATURE \_\_\_\_\_ SAMPLER \_\_\_\_\_

---

SIGNATURE \_\_\_\_\_

For 2" well .16(h) = Vol. in gallons  
 For 4" well .65(h) = Vol. in gallons  
 C-5

Bailers

length	diameter	Volume
3'	1.5"	0.27
5'	1.5"	0.45
3'	3"	1.1

AR301656

# **MONITORING WELL PURGING FORM**

WELL NO. <u>AR 2</u>	
WELL/SITE DESCRIPTION: <u>Arnonian Plating</u>	
DATE: <u>2/6/91</u>	TIME: <u>11:58</u> WEATHER AIR TEMP: _____

WELL DEPTH <u>22.40</u> FT (TOP OF PVC)	PVC STICK-UP HT. _____ FT
WATER DEPTH <u>16.63</u> FT (TOP OF PVC)	CASING HT. _____ FT
WATER COLUMN HEIGHT <u>5.77</u> FT	WELL DIAMETER _____ IN.
EQUIVALENT VOLUME OF STANDING WATER <u>0.92</u> (GAL) [ $V = \pi r^2 h$ , 7.48 GAL = 1 cft]	SANDPACK DIAM. _____ IN.
VOLUME OF BAILER <u>0.27</u> (GAL) <input checked="" type="checkbox"/> or PUMP RATE _____ (GPM)	
TOTAL NO. OF BAILERS (3-5 EQUIV.) <u>~15</u> or PUMP TIME _____ MIN.	
WELL WENT DRY? (Y/N) <u>N</u> NO. OF BAILERS <u>34</u> or PUMP TIME _____	
VOL. REMOVED <u>8.5</u> (GAL)	RECOVERY TIME _____ MIN.
PURGE AGAIN? (Y/N) <u>N</u>	TOTAL VOL. REMOVED _____ (GAL)

	TIME	pH	TEMP (°F)	COND (UMHO/CM)
INITIAL T(O)	<u>12:03</u>	<u>7.37</u>	<u>57</u>	<u>140</u>
DURING	<u>12:06</u>	<u>7.08</u>	<u>57</u>	<u>240</u>
DURING	<u>12:09</u>	<u>6.64</u>	<u>57</u>	<u>440</u>
DURING	<u>12:12</u>	<u>6.52</u>	<u>57</u>	<u>520</u>
DURING	<u>12:15</u>	<u>6.48</u>	<u>57</u>	<u>610</u>
FINAL During	<u>12:17</u>	<u>6.45</u>	<u>57</u>	<u>680</u>
During	<u>12:19</u>	<u>6.41</u>	<u>57</u>	<u>720</u>
	<u>12:22</u>	<u>6.43</u>	<u>57</u>	<u>740</u>

CHK ANALYSIS	SAMPLE CONTAINER NO.	REMARKS (FILTERED/PRESERVED, ETC.)
<input checked="" type="checkbox"/> VOA	<u>40 ml glass vials 2</u>	<u>2 drops HCl preserved in field</u>
<input checked="" type="checkbox"/> CN <sup>-</sup>	<u>1-liter poly 1</u>	<u>NaOH 1 by lab</u>
<input checked="" type="checkbox"/> Total Metals	<u>1 1</u>	<u>HAB<sub>3</sub></u>
<input checked="" type="checkbox"/> Filtered	<u>1 1</u>	<u>1 1 1 1 ; (Filtered)</u>

TOTAL NUMBER OF CONTAINERS FOR SAMPLE 5

DESCRIPTION OF SAMPLE CONDITIONS		
SAMPLE COLOR _____	ODOR _____	HNU READING _____
HIGH CONCENTRATIONS EXPECTED? _____	HIGH HAZARD? _____	
UNUSUAL FEATURES _____		
WEATHER/TEMPERATURE _____		SAMPLER _____

SIGNATURE \_\_\_\_\_

For 2" well .16(h) = Vol in gallons  
 For 4" well .65(h) = Vol in gallons

C-5

length	diameter	Volume (gallons)
3'	1.5"	0.27
5'	1.5"	0.45
3'	3"	
5'	2"	

**AR301657**

# MONITORING WELL PURGING FORM

WELL NO. AR3

WELL/SITE DESCRIPTION: Arrandale Plating

DATE: 2/6/91

TIME: 11:03

WEATHER AIR TEMP: \_\_\_\_\_

WELL DEPTH 18.84 FT (TOP OF PVC)

PVC STICK-UP HT. \_\_\_\_\_ FT

WATER DEPTH 20.50 FT (TOP OF PVC)

CASING HT. \_\_\_\_\_ FT

WATER COLUMN HEIGHT 10.34 FT

WELL DIAMETER \_\_\_\_\_ IN.

EQUIVALENT VOLUME OF STANDING WATER 165 (GAL) [V =  $\pi r^2 h$ , 7.48 GAL = 1 cft]

SANDPACK DIAM. \_\_\_\_\_ IN.

VOLUME OF BAILER 0.27 (GAL) MS or PUMP RATE \_\_\_\_\_ (GPM)

TOTAL NO. OF BAILERS (3-5 EQUIV.) 20-15 or PUMP TIME \_\_\_\_\_ MIN.

WELL WENT DRY? (Y/N) N NO. OF BAILERS 20 or PUMP TIME \_\_\_\_\_

VOL. REMOVED 5 (GAL) RECOVERY TIME \_\_\_\_\_ MIN.

PURGE AGAIN? (Y/N) N TOTAL VOL. REMOVED \_\_\_\_\_ (GAL)

	TIME	pH	TEMP (°F)	COND (UMHO/CM)
INITIAL T(0)	11:10	6.37	57	530
DURING	11:15	6.29	57	550
DURING	11:17	6.38	57	530
DURING	11:20	6.39	57	510
FINAL	11:23	6.36	57	480
Final	11:26	6.36	57	480

CHK ANALYSIS SAMPLE CONTAINER NO. REMARKS (FILTERED/PRESERVED, ETC.)

✓ VOA	40ml glass vials	2	2 drops HCl preserved in field
✓ CN <sup>-</sup>	1-liter poly	1	NaOH by lab
✓ total metals	✓	1	HNO <sub>3</sub>
✓ Filtered	✓	1	✓ ✓ ✓ (filtered)

TOTAL NUMBER OF CONTAINERS FOR SAMPLE 5

## DESCRIPTION OF SAMPLE CONDITIONS

SAMPLE COLOR \_\_\_\_\_ ODOR \_\_\_\_\_ HNU READING \_\_\_\_\_

HIGH CONCENTRATIONS EXPECTED? \_\_\_\_\_ HIGH HAZARD? \_\_\_\_\_

UNUSUAL FEATURES \_\_\_\_\_

WEATHER/TEMPERATURE \_\_\_\_\_ SAMPLER \_\_\_\_\_

SIGNATURE \_\_\_\_\_

For 2" well .16(h) = Vol. in gallons  
For 4" well .65(h) = Vol. in gallons  
C-5

length	diameter	Volume (g)
3'	1.5"	0.27
5'	1.5"	0.45
3'	3"	1.1

5-AR3016588

**APPENDIX D**

**SURFACE WATER AND SEDIMENT SAMPLING  
FORMS**

**AR301659**

# SURFACE WATER AND SEDIMENT SAMPLE COLLECTION FORM

STATION NUMBER ST1  
 DESCRIPTION OF LOCATION: Uppermost Sample (site drawings)  
 DATE: 4/11/90 TIME: 1920 WEATHER AIR TEMP: 70°F

## SURFACE WATER

### FIELD SCREENING MEASUREMENTS:

pH	<u>NA</u>	Eh	<u>75.</u>
Temp.	<u>53°F/12°C</u>	D.O.	<u>8.5 mg/l</u>
Conductivity	<u>410 µS</u>	PID	<u>NA</u>

LABORATORY PARAMETERS: VOA; Metals (filtered unfiltered); CYN (unfiltered)  
ST1 - SW1  
TSS; BNA; Hardness

OBSERVATIONS: Water = 3" deep (shallow)

## SEDIMENT

### DESCRIPTION:

COLOR lt. brown → gray Clay TOTAL DEPTH: 6"  
 PARTICLE SIZE/STRATIGRAPHY .75"-2" light brown f-m SAND, trace f Gravel; overlying dark gray Clay. In one sample (larger) 4" deep a layer of black discolored Clay was encountered w/ slight color

### FIELD SCREENING MEASUREMENTS:

pH	<u>NA</u>	Eh	<u>48</u>
Temp.	<u>53°F/12°C</u>	D.O.	<u>4.25 mg/l</u>
Conductivity	<u>90 µS</u>	PID	<u>NA</u>

LABORATORY PARAMETERS: VOA; BNA; metals/CYN; grain size, TC  
% moisture, % solid

OBSERVATIONS: \_\_\_\_\_

SIGNATURE

Claudia A. Brand

# SURFACE WATER AND SEDIMENT SAMPLE COLLECTION FORM

STATION NUMBER ST 2

DESCRIPTION OF LOCATION: Downstream of lumber yard

DATE: 7/11/90

TIME: 1751

WEATHER AIR TEMP: 70°F

## SURFACE WATER

### FIELD SCREENING MEASUREMENTS:

pH	<u>NA</u>	Eh	<u>66</u>
Temp.	<u>54°F/13°C</u>	D.O.	<u>2.4 mg/l</u>
Conductivity	<u>320 u/s</u>	PID	<u>NA</u>

LABORATORY PARAMETERS: VOA; Metals (filtered samples); CYN (unfiltered)  
ST 2 - SW1 TSS; BNA; Hardness (Collected. duplicate SW1A)  
ST 2 - SW1A

OBSERVATIONS: Shallow water = 4" deep; Orange color to  
Sediments along edges (water clearish)  
NA

## SEDIMENT

### DESCRIPTION:

COLOR brown → grey TOTAL DEPTH: 6"  
 PARTICLE SIZE/STRATIGRAPHY 0.5" orange brown f-c SAND, overlying light  
grey w/mottling clay, little f sand w/ little w-f-c Gravel in upper part

### FIELD SCREENING MEASUREMENTS:

pH	<u>NA</u>	Eh	<u>-29</u>
Temp.	<u>11°C/58°F</u>	D.O.	<u>3.6 mg/l</u>
Conductivity	<u>110 u/s</u>	PID	<u>NA</u>

LABORATORY PARAMETERS: VOA; BNA; Metals/CYN; Grain Size; TOC  
percent moisture, percent solid

OBSERVATIONS: See "observations" above.

SIGNATURE Charles E. Brund

# SURFACE WATER AND SEDIMENT SAMPLE COLLECTION FORM

STATION NUMBER <u>ST 3</u>	
DESCRIPTION OF LOCATION: <u>Start of slow flow meandering</u>	
DATE: <u>4/9/90</u>	TIME: <u>1735</u> WEATHER AIR TEMP: <u>73°F</u>

SURFACE WATER			
FIELD SCREENING MEASUREMENTS:			
pH	<u>NA</u>	Eh	<u>169.</u>
Temp.	<u>56°F/13°C</u>	D.O.	<u>7.9 mg/l</u>
Conductivity	<u>160 µS</u>	PID	<u>NA</u>
LABORATORY PARAMETERS: <u>VOA, Metals (filtered + unfiltered), CYN (unfiltered), TSS, BNA, Hardness</u>			
OBSERVATIONS: <u>Shallow water ~ 4", clear, flowing mildly, up slope</u>			

SEDIMENT			
DESCRIPTION:			
COLOR <u>1.4/2 brown</u>	TOTAL DEPTH: <u>6"</u>		
PARTICLE SIZE/STRATIGRAPHY <u>5" f-c SAND, bottom 1" dark grey f-c Sand w/ some leaves + organic matter</u>			
FIELD SCREENING MEASUREMENTS:			
pH	<u>NA</u>	Eh	<u>120</u>
Temp.	<u>56°F/13°C</u>	D.O.	<u>7 mg/l</u>
Conductivity	<u>160 µS</u>	PID	<u>NA</u>
LABORATORY PARAMETERS: <u>VOA, Metals / CYN, BNA, Grain Size, TOC, % Moisture, % Solid</u>			
OBSERVATIONS: <u>grade drops + stream meanders</u>			

SIGNATURE	<u>Charles E. Brown</u>
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# SURFACE WATER AND SEDIMENT SAMPLE COLLECTION FORM

STATION NUMBER <u>ST4</u>	
DESCRIPTION OF LOCATION: <u>Other branch</u>	
DATE: <u>7/9/90</u>	TIME: <u>1635</u> WEATHER AIR TEMP: <u>78°F</u>

**SURFACE WATER**

FIELD SCREENING MEASUREMENTS:

pH	<u>NA</u>	Eh	<u>17.9</u>
Temp.	<u>58°F</u>	D.O.	<u>7.4 mg/l</u>
Conductivity	<u>80 u/s</u>	PID	<u>NA</u>

LABORATORY PARAMETERS: VOA; Metals (Silver & Infilon); CYN, TSS;  
BNA; Hardness

OBSERVATIONS: Depth of water = 0.6"

**SEDIMENT**

DESCRIPTION:

COLOR top inch = orange  
5" = dark gray clay TOTAL DEPTH: 6"

PARTICLE SIZE/STRATIGRAPHY 1" orange-f-m SAND over 5" dark gray clay  
Some f-m SAND, organic matter, roots, little of gravel

FIELD SCREENING MEASUREMENTS:

pH	<u>NA</u>	Eh	<u>7</u>
Temp.	<u>15°C</u>	D.O.	<u>0.48 mg/l</u>
Conductivity	<u>60 u/s</u>	PID	<u>NA</u>

LABORATORY PARAMETERS: VOA; Metals/CYN; BNA; Grain size, TOC,  
% moisture, % solids; Bioassay (Ceriodaphnia)

OBSERVATIONS: Composited c 4 samples collected from adjacent locations +  
mixed on polyethylene sheeting prior to sampling (except VOA's sampled first)

SIGNATURE Charles A. Brown

STATION NUMBER 575

DESCRIPTION OF LOCATION: After confluence w/ other b. branch; downstream of where S. water  
is not  
present

DATE: 4/9/90 TIME: 1550 WEATHER AIR TEMP: 73°F

**SURFACE WATER**

FIELD SCREENING MEASUREMENTS:

pH	<u>NA</u>	Eh	<u>110.</u>
Temp.	<u>6.3°F / 17°C</u>	D.O.	<u>6.8 mg/l</u>
Conductivity	<u>90 u/s</u>	PID	<u>NA</u>

LABORATORY PARAMETERS: VOA; Metals (filt + unfilt.); CYN; SS; BNA;  
Hardness

OBSERVATIONS: Depth of water = 0.6"; many water bugs observed;  
water appears clear very little turbidity.

**SEDIMENT**

DESCRIPTION:

COLOR light brown on surface  
grey below TOTAL DEPTH: 6"

PARTICLE SIZE/STRATIGRAPHY fine SAND overlying dark grey CLAY w/  
some fine sand

FIELD SCREENING MEASUREMENTS:

pH	<u>NA</u>	Eh	<u>-16</u>
Temp.	<u>15°C</u>	D.O.	<u>0.5 mg/l</u>
Conductivity	<u>70 u/s</u>	-PID	<u>NA</u>

LABORATORY PARAMETERS: VOA; Metals/CYN; BNA; Grain Size  
DOC; % Moisture; % Solids

OBSERVATIONS: Composited ~ 4 layers on piece of plastic sheeting using  
hand ~~auger~~ trowel prior to sampling (except VOA's sampled first)

SIGNATURE Christie LeGrand

# SURFACE WATER AND SEDIMENT SAMPLE COLLECTION FORM

STATION NUMBER 5T6  
 DESCRIPTION OF LOCATION: Inflow to Wagners Mill Pond  
 DATE: 4/9/90 TIME: 1220 WEATHER AIR TEMP: 73°F

## SURFACE WATER

### FIELD SCREENING MEASUREMENTS:

pH <sup>meter</sup> <sub>boke</sub> NA Eh 127.2  
 Temp. 19°C D.O. 9 mg/l  
 Conductivity 50 u/s PID NA  
 (finite or infinite) (infinite)

LABORATORY PARAMETERS: VOA; Metals; CYN; TSS/ALK; BNA;  
Hardness; BOD assay (Cenodiphon + Ferrous Sulphate)

OBSERVATIONS: Water depth = 1.0', clear, channel is surrounded  
by thick, soft sediment

## SEDIMENT

### DESCRIPTION:

COLOR Med dark grey TOTAL DEPTH: 6-8'

### PARTICLE SIZE/STRATIGRAPHY

Very thin layer of light brown SAND w/ little f-c gravel over CLAY,  
some f-c Sand, % of Sand decreases w/ depth

### FIELD SCREENING MEASUREMENTS:

pH NA Eh -113  
 Temp. 22°C D.O. 0.6 mg/l  
 Conductivity 140 u/s PID       

LABORATORY PARAMETERS: VOA; Metals/CYN; BNA; Grain Size;  
TOC/% Moisture, % Solid

OBSERVATIONS: Orange brown suspended material present near surface in  
water (incorporated into sample). Collection method involved sampling from various portions of  
various layers to mix material (as a control comparison)

SIGNATURE

Charles A. Brune

# SURFACE WATER AND SEDIMENT SAMPLE COLLECTION FORM

STATION NUMBER

ST 7

DESCRIPTION OF LOCATION:

WEAVERS MILLPOND - PIERCE CREEK

DATE: 4/9/90

TIME: 1100

WEATHER AIR TEMP: 23°C

## SURFACE WATER

### FIELD SCREENING MEASUREMENTS:

pH	<u>6.33</u>	Eh	<u>160</u>
Temp.	<u>48°F</u>	D.O.	<u>4.6 mg/l</u>
Conductivity	<u>30 u/s</u>	PID	<u>NA</u>

LABORATORY PARAMETERS: VOA; Metals (filtered + unfiltered); CYN (unfiltered)  
TSS/ALK; BNA; Hardness

OBSERVATIONS: Water  
Depth = 0.9' Appeared generally clear with  
slight turbidity, rapidly flowing discharge to Pierce Creek  
location of sampling is off to side not in fastest flowing section

## SEDIMENT

### DESCRIPTION:

COLOR Med. dark grey TOTAL DEPTH: 6"  
 PARTICLE SIZE/STRATIGRAPHY CLAY and f SAND; trace gravel and  
rocks on surface. Organic layer is relatively thin

FIELD SCREENING MEASUREMENTS: 50 ml of material in beaker w/ 50 ml of distilled  
water allowed to sit 5 min

pH	<u>7.25</u>	Eh	<u>-32</u>
Temp.	<u>61°F/17°C</u>	D.O.	<u>0.5 mg/l</u>
Conductivity	<u>20 u/s</u>	PID	<u>NA</u>

LABORATORY PARAMETERS: VOA; Metals; CYN; BNA; Grain size;  
TDC; % Moisture, % Solid

OBSERVATIONS: Sample collection involved collecting from various portions of various layers (taken from 5'  
spot) to mix material

SIGNATURE

Charles C. Brand

# SURFACE WATER AND SEDIMENT SAMPLE COLLECTION FORM

STATION NUMBER <u>ST1</u>	
DESCRIPTION OF LOCATION: <u>Upstream sample site (downstream)</u>	
DATE: <u>5/24/90</u>	TIME: <u>0850</u> WEATHER AIR TEMP: <u>70°</u>

SURFACE WATER

FIELD SCREENING MEASUREMENTS:

pH	<u>7.1/7.26</u>	Eh	<u>-3</u>
Temp.	<u>59.1°F/14°C</u>	D.O.	<u>9.6</u>
Conductivity	<u>526</u>	PID	<u></u>

LABORATORY PARAMETERS: VOA; Metals (filtered + total); CN; RNA; TSS  
Duplicate collected

OBSERVATIONS: Water fairly clear, ~1" deep, low to moderate flow.

SEDIMENT

DESCRIPTION:

COLOR  TOTAL DEPTH: 7"

PARTICLE SIZE/STRATIGRAPHY top 3" orange brown M-C SAND; Remainder is grey CLAY; (little f-m gravel)

FIELD SCREENING MEASUREMENTS: 50ml Sed / 50ml D.I.

pH	<u>6.25/6.80</u>	Eh	<u>14</u>
Temp.	<u>60.3°F</u>	D.O.	<u>0.8</u>
Conductivity	<u>141</u>	PID	<u></u>

LABORATORY PARAMETERS: Metals; RNA; CN; VOA

OBSERVATIONS:

SIGNATURE



# SURFACE WATER AND SEDIMENT SAMPLE COLLECTION FORM

STATION NUMBER ST 3  
 DESCRIPTION OF LOCATION: Start of river / mid channel  
 DATE: 5/23/90 TIME: 1715 WEATHER AIR TEMP: 75°

## SURFACE WATER

### FIELD SCREENING MEASUREMENTS:

pH	<u>7.17</u>	Eh	<u>-10</u>
Temp.	<u>15.9°C / 60.6°F</u>	D.O.	<u>7.4</u>
Conductivity	<u>336</u>	PID	

LABORATORY PARAMETERS: VOA; Metals (filtered & total); BVA; CN;  
TSS

OBSERVATIONS: Fairly clear, slower flow; ~1" deep

## SEDIMENT

### DESCRIPTION:

COLOR \_\_\_\_\_ TOTAL DEPTH: 6"  
 PARTICLE SIZE/STRATIGRAPHY Orange-brown f-m SAND, trace c. Sand,  
trace Silt.

FIELD SCREENING MEASUREMENTS: 50 ml Sed: 50 ml DI.

pH	<u>6.27</u>	Eh	<u>-000</u>
Temp.	<u>18.1°C / 64.3°F</u>	D.O.	<u>3.5</u>
Conductivity	<u>259</u>	PID	

LABORATORY PARAMETERS: VOA; Metals; CN; BVA

OBSERVATIONS: \_\_\_\_\_

SIGNATURE \_\_\_\_\_

# SURFACE WATER AND SEDIMENT SAMPLE COLLECTION FORM

STATION NUMBER <u>ST4</u>	
DESCRIPTION OF LOCATION: <u>Rd. creek</u>	
DATE: <u>5/23/90</u>	TIME: <u>16:25</u> WEATHER AIR TEMP: <u>75°</u>

**SURFACE WATER**

FIELD SCREENING MEASUREMENTS:

pH	<u>5.26/6.15</u>	Eh	<u>-1</u>
Temp.	<u>16.6/15.8 F</u>	D.O.	<u>9.55</u>
Conductivity	<u>152</u>	PID	<u>      </u>

LABORATORY PARAMETERS: WAP, Metals (filtered + total), NH<sub>4</sub>  
CH, TSS

OBSERVATIONS: Water flowing moderately fast; fairly clear,  
appears 4" deep

**SEDIMENT**

DESCRIPTION:

COLOR        TOTAL DEPTH: 8"

PARTICLE SIZE/STRATIGRAPHY Top 1/8" orange brown m-c SAND; Remainder  
is light grey CLAY, trace f sand.

FIELD SCREENING MEASUREMENTS: SD and sed: SZ and DT

pH	<u>6.47</u>	Eh	<u>-9</u>
Temp.	<u>66.6 F</u>	D.O.	<u>0.2</u>
Conductivity	<u>143</u>	PID	<u>      </u>

LABORATORY PARAMETERS: Metals CN; BUA

OBSERVATIONS:       

SIGNATURE

# SURFACE WATER AND SEDIMENT SAMPLE COLLECTION FORM

STATION NUMBER <u>ST5</u>	
DESCRIPTION OF LOCATION: <u>junction of creek near the beach /</u>	
DATE: <u>5/23/90</u>	TIME: <u>1237</u> WEATHER AIR TEMP: <u>75</u>

SURFACE WATER			
FIELD SCREENING MEASUREMENTS:			
pH	<u>6.88/6.90</u>	Eh	<u>-13.</u>
Temp.	<u>18.6/19.5°F</u>	D.O.	<u>4.4</u>
Conductivity	<u>205</u>	PID	<u>      </u>
LABORATORY PARAMETERS: <u>VCA; Metals (filtered + total), CN, BNA,</u> <u>TSS</u>			
OBSERVATIONS: <u>Moderate flow, ~6" deep, stream is filled w/</u> <u>tan/orange brown sands - critical flow possible.</u>			

SEDIMENT			
DESCRIPTION:			
COLOR <u>      </u>	TOTAL DEPTH: <u>7"</u>		
PARTICLE SIZE/STRATIGRAPHY <u>Top 1" orange brown f-m SAND.</u> <u>Remaining 6" dark grey fine SAND w/ some (-) Clay</u>			
FIELD SCREENING MEASUREMENTS: <u>50 ml Sed: 50 ml DT</u>			
pH	<u>6.73/6.83</u>	Eh	<u>-10</u>
Temp.	<u>70.5°F</u>	D.O.	<u>0.2</u>
Conductivity	<u>103</u>	PID	<u>      </u>
LABORATORY PARAMETERS: <u>Metals; BNA; CN; VCA</u>			
OBSERVATIONS: <u>      </u>			
SIGNATURE <u>      </u>			

# SURFACE WATER AND SEDIMENT SAMPLE COLLECTION FORM

STATION NUMBER ST6

DESCRIPTION OF LOCATION: Surface to 2000 ft. Mill Pond

DATE: 5/23/90

TIME: 11:45

WEATHER AIR TEMP: 75°

## SURFACE WATER

FIELD SCREENING MEASUREMENTS: NOTE: Groundwater 150 ft. from surface

pH	<u>6.84/6.44</u>	Eh	<u>-12</u>
Temp.	<u>22°C/71.4°F</u>	D.O.	<u>7 C</u>
Conductivity	<u>212</u>	PID	<u>      </u>

LABORATORY PARAMETERS: VOA; Metals (filtered + total); BNA, CN;  
TSS

OBSERVATIONS: Moderate flow, ~ 8' deep, water turbulent

## SEDIMENT

DESCRIPTION:

COLOR        TOTAL DEPTH: 6"

PARTICLE SIZE/STRATIGRAPHY 1/4" f-m org. brown SAND, trace f-m  
gravel, remainder - light grey clay, trace roots

FIELD SCREENING MEASUREMENTS: 50 ml sed 50 ml DI. (trace, ca 1415 @ time)

pH	<u>6.71/6.72</u>	Eh	<u>-14</u>
Temp.	<u>71.1°F</u>	D.O.	<u>0.9</u>
Conductivity	<u>60</u>	PID	<u>      </u>

LABORATORY PARAMETERS: VOA; Metals; CN; BNA

OBSERVATIONS:       

SIGNATURE

# SURFACE WATER AND SEDIMENT SAMPLE COLLECTION FORM

STATION NUMBER <u>ST 7</u>	
DESCRIPTION OF LOCATION: <u>Lower Mill Pond - Pine Creek</u>	
DATE: <u>5/23</u>	TIME: <u>1100</u> WEATHER AIR TEMP: <u>75</u>

SURFACE WATER			
FIELD SCREENING MEASUREMENTS:			
pH	<u>6.75/6.55</u>	Eh	<u>-4</u>
Temp.	<u>64.3°F/16.5°C</u>	D.O.	<u>11.8C</u>
Conductivity	<u>129</u>	PID	<u>      </u>
LABORATORY PARAMETERS: <u>VCA; Metals (filtered + total) BNA</u>			
<u>CN, TSS</u>			
OBSERVATIONS: <u>flowing rapidly, ~1.5' deep, weak brown tint</u>			

SEDIMENT			
DESCRIPTION: <u>1/4" f-m SAND; remainder = lt grey CLAY w/ trace green.</u>			
COLOR <u>      </u>	TOTAL DEPTH: <u>8"</u>		
PARTICLE SIZE/STRATIGRAPHY <u>      </u>			
<u>      </u>			
FIELD SCREENING MEASUREMENTS: <u>50 ml Sed / 50 ml DI H<sub>2</sub>O (note: 14/56 held.)</u>			
pH	<u>6.78/6.57</u>	Eh	<u>-17</u>
Temp.	<u>75.7</u>	D.O.	<u>0.8C</u>
Conductivity	<u>147</u>	PID	<u>      </u>
LABORATORY PARAMETERS: <u>VCA; Metals; CN, BNA</u>			
<u>      </u>			
OBSERVATIONS: <u>      </u>			
<u>      </u>			
SIGNATURE <u>      </u>			

# SURFACE WATER AND SEDIMENT SAMPLE COLLECTION FORM

STATION NUMBER <u>MF-SW1</u>	
DESCRIPTION OF LOCATION: <u>wooded area ; ravine</u>	
DATE: <u>2/6/91</u>	TIME: <u>3:30 pm</u> WEATHER AIR TEMP: _____

<b>SURFACE WATER</b>	
FIELD SCREENING MEASUREMENTS:	
pH _____	Eh _____
Temp. _____	D.O. _____
Conductivity _____	PID _____
LABORATORY PARAMETERS: <u>VOAs</u>	
OBSERVATIONS: <u>Sample taken from groundwater seep. Water dripping sampled to fill vial since not able to obtain zero headspace while vial in vertical horizontal position to collect seep.</u>	

<b>SEDIMENT</b>	
DESCRIPTION:	
COLOR _____	TOTAL DEPTH: _____
PARTICLE SIZE/STRATIGRAPHY _____	
FIELD SCREENING MEASUREMENTS:	
pH _____	Eh _____
Temp. _____	D.O. _____
Conductivity _____	PID _____
LABORATORY PARAMETERS: _____	
OBSERVATIONS: _____	
SIGNATURE _____	

# SURFACE WATER AND SEDIMENT SAMPLE COLLECTION FORM

STATION NUMBER		<u>MF-SD1</u>	
DESCRIPTION OF LOCATION:		<u>wooded area; ravine</u>	
DATE: <u>2/6/91</u>	TIME: <u>3:35 PM</u>	WEATHER AIR TEMP: _____	
<b>SURFACE WATER</b>			
FIELD SCREENING MEASUREMENTS:			
pH	_____	Eh	_____
Temp.	_____	D.O.	_____
Conductivity	_____	PID	_____
LABORATORY PARAMETERS: _____			
OBSERVATIONS: _____			
<b>SEDIMENT</b>			
DESCRIPTION:			
COLOR <u>Brown</u>	TOTAL DEPTH: <u>0-4"</u>		
PARTICLE SIZE/STRATIGRAPHY _____			
FIELD SCREENING MEASUREMENTS:			
pH	_____	Eh	_____
Temp.	_____	D.O.	_____
Conductivity	_____	PID	_____
LABORATORY PARAMETERS: <u>VOAs</u>			
OBSERVATIONS: <u>Sampled with trowel about 30' down in ravine;</u> <u>taken near MF-SD1.</u>			
SIGNATURE _____			

1

STATION NUMBER	<u>MF2-SW1</u>		
DESCRIPTION OF LOCATION:	<u>Small stream in wooded ravine</u>		
DATE: <u>2/6/91</u>	TIME: <u>3:40</u>	WEATHER	AIR TEMP: _____

---

SURFACE WATER

FIELD SCREENING MEASUREMENTS:

pH	_____	Eh	_____
Temp.	_____	D.O.	_____
Conductivity	_____	PID	_____

LABORATORY PARAMETERS: VOAs

---

OBSERVATIONS: Only 1 vial taken from stream running @ 2" deep.

---

SEDIMENT

DESCRIPTION:

COLOR \_\_\_\_\_ TOTAL DEPTH: \_\_\_\_\_

PARTICLE SIZE/STRATIGRAPHY \_\_\_\_\_

---

FIELD SCREENING MEASUREMENTS:

pH	_____	Eh	_____
Temp.	_____	D.O.	_____
Conductivity	_____	PID	_____

LABORATORY PARAMETERS: \_\_\_\_\_

---

OBSERVATIONS: \_\_\_\_\_

---

SIGNATURE \_\_\_\_\_

# SURFACE WATER AND SEDIMENT SAMPLE COLLECTION FORM

STATION NUMBER SF-SW1  
 DESCRIPTION OF LOCATION: wooded area; ravine  
 DATE: 2/6/91 TIME: 3:45 PM WEATHER AIR TEMP: \_\_\_\_\_

## SURFACE WATER

### FIELD SCREENING MEASUREMENTS:

pH _____	Eh _____
Temp. _____	D.O. _____
Conductivity _____	PID _____

LABORATORY PARAMETERS: VOAs

OBSERVATIONS: Sample taken from groundwater seep; seepage filled vials quickly (~3 secs):

## SEDIMENT

### DESCRIPTION:

COLOR \_\_\_\_\_ TOTAL DEPTH: \_\_\_\_\_  
 PARTICLE SIZE/STRATIGRAPHY \_\_\_\_\_

### FIELD SCREENING MEASUREMENTS:

pH _____	Eh _____
Temp. _____	D.O. _____
Conductivity _____	PID _____

LABORATORY PARAMETERS: \_\_\_\_\_

OBSERVATIONS: \_\_\_\_\_

SIGNATURE \_\_\_\_\_

# SURFACE WATER AND SEDIMENT SAMPLE COLLECTION FORM

STATION NUMBER <u>SF-SD1</u>	
DESCRIPTION OF LOCATION: <u>wooded area ravine</u>	
DATE: <u>2/6/91</u>	TIME: <u>4:00 PM</u> WEATHER AIR TEMP: _____

SURFACE WATER

FIELD SCREENING MEASUREMENTS:

pH _____	Eh _____
Temp. _____	D.O. _____
Conductivity _____	PID _____

LABORATORY PARAMETERS: VOAs

OBSERVATIONS: Sample taken with trowel near SF-SD1 sample location from 0-2" deep. Very wet sediment.

SEDIMENT

DESCRIPTION:

COLOR \_\_\_\_\_ TOTAL DEPTH: \_\_\_\_\_

PARTICLE SIZE/STRATIGRAPHY \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

FIELD SCREENING MEASUREMENTS:

pH _____	Eh _____
Temp. _____	D.O. _____
Conductivity _____	PID _____

LABORATORY PARAMETERS: \_\_\_\_\_

\_\_\_\_\_

OBSERVATIONS: \_\_\_\_\_

\_\_\_\_\_

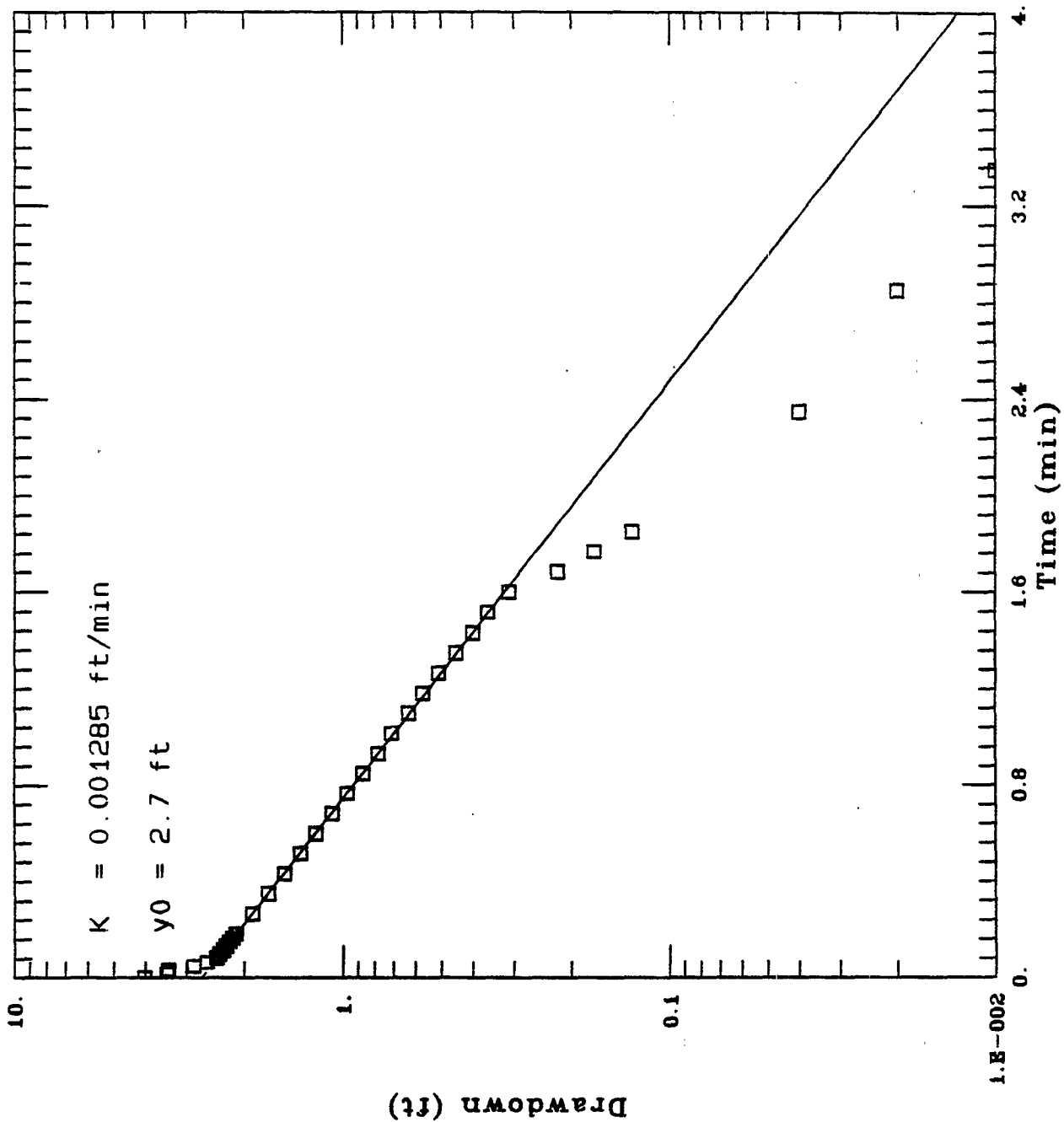
SIGNATURE \_\_\_\_\_

**APPENDIX E**

**SLUG TEST DATA WITH GRAPHICAL RESULTS**

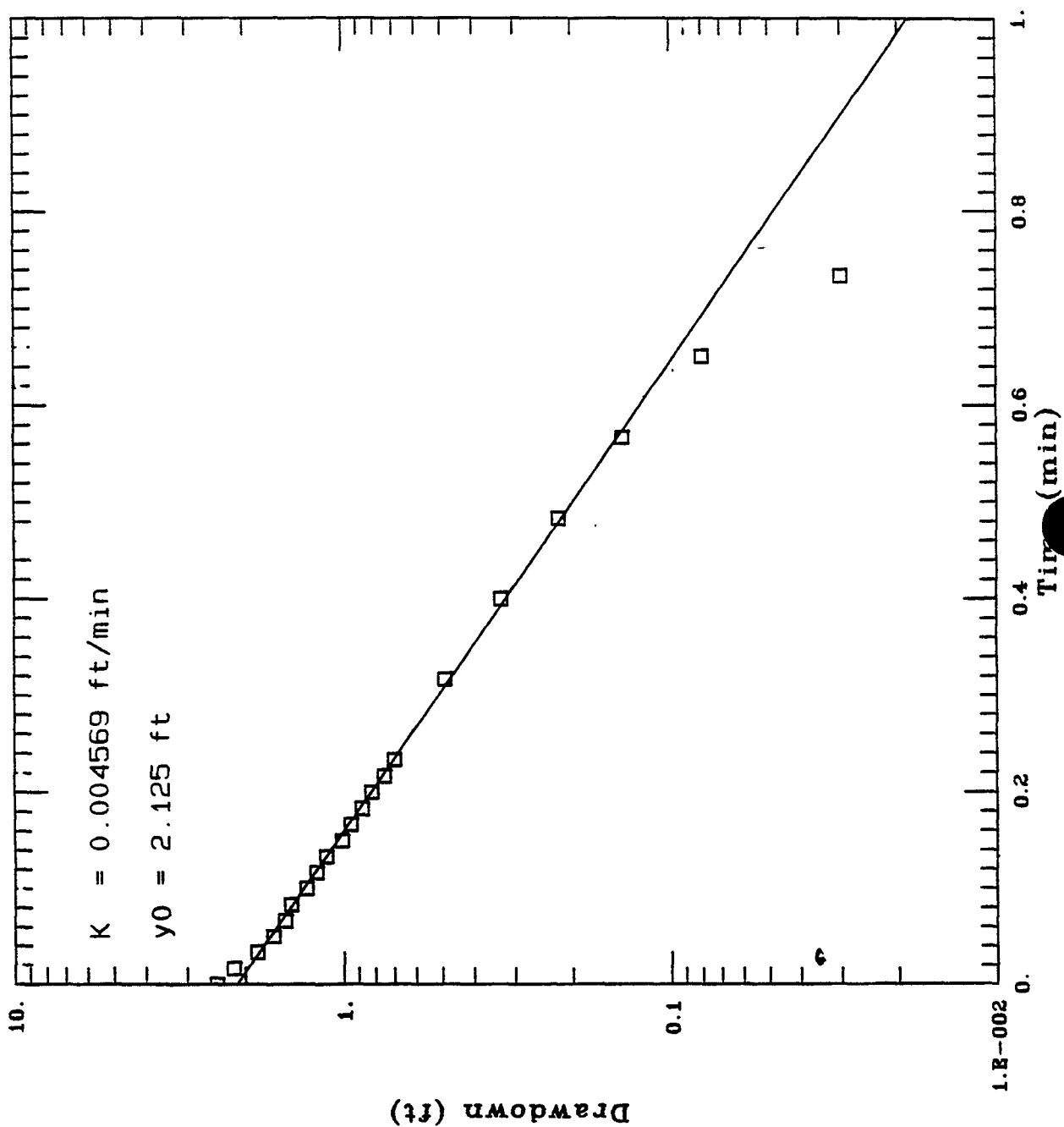
**AR301679**

# Falling Head Slug Test: MW-1



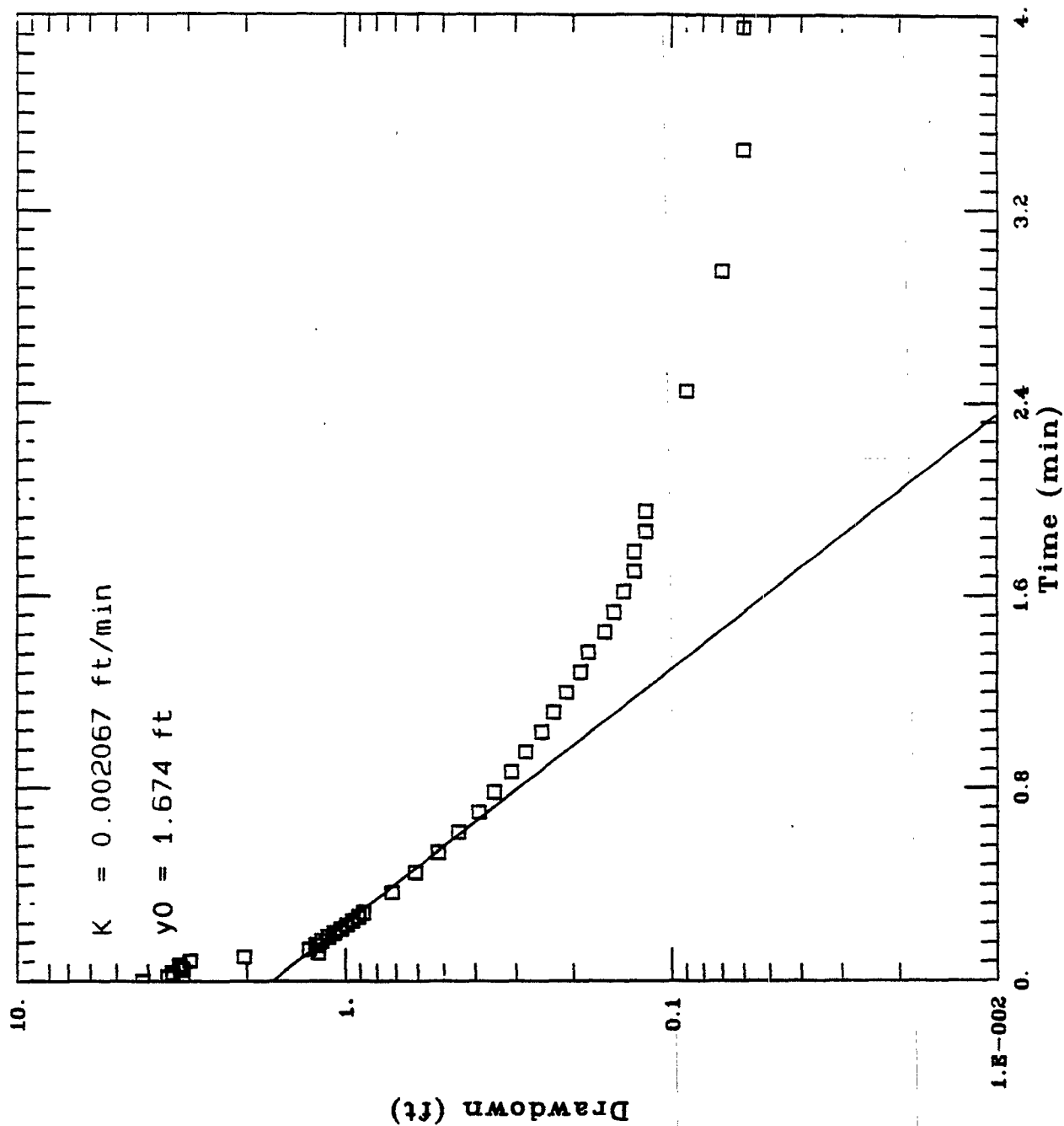
AR301680

# Rising Head Slug Test: MW-1



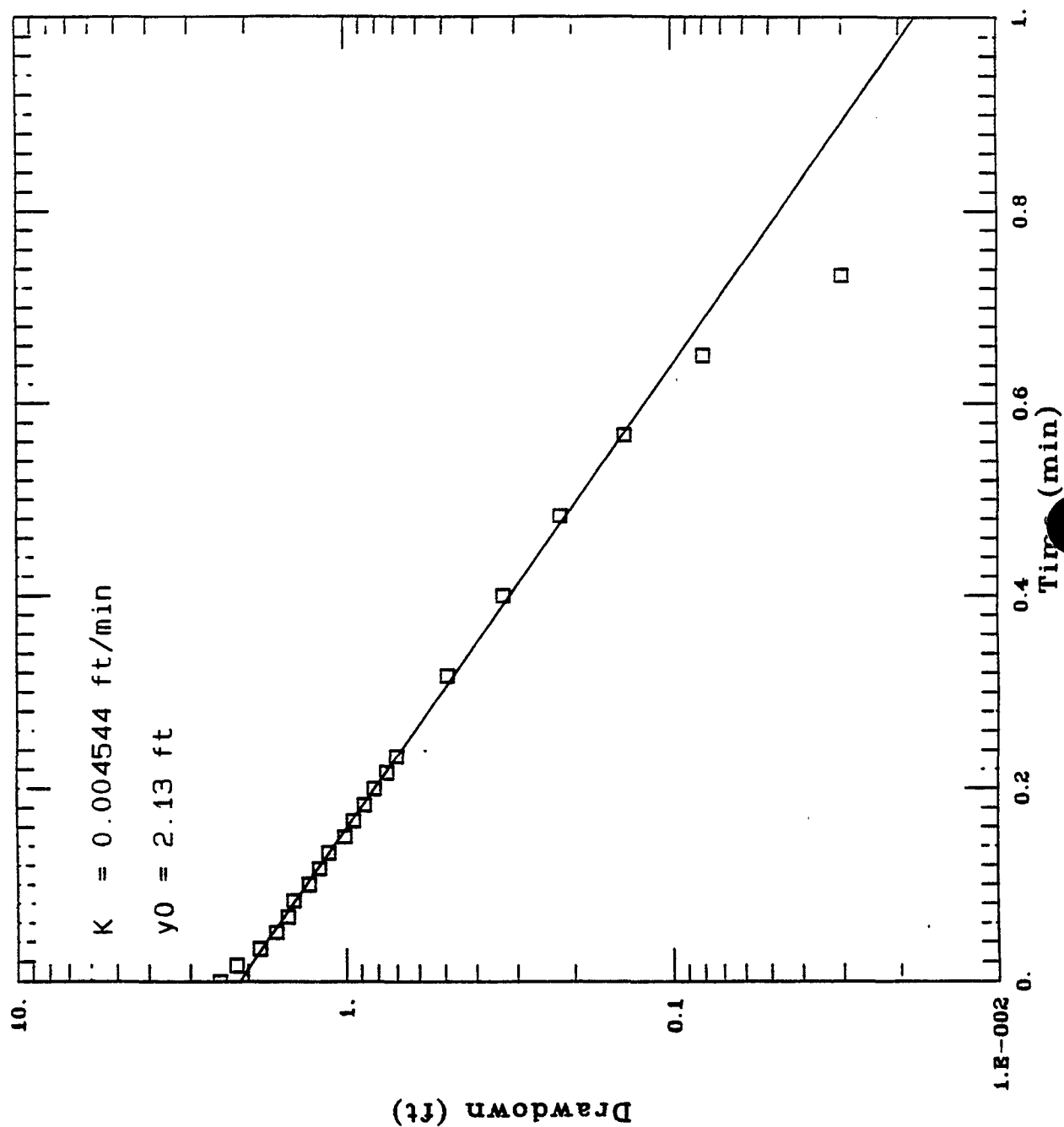
AR301681

# Falling Head Slug Test: MW-2



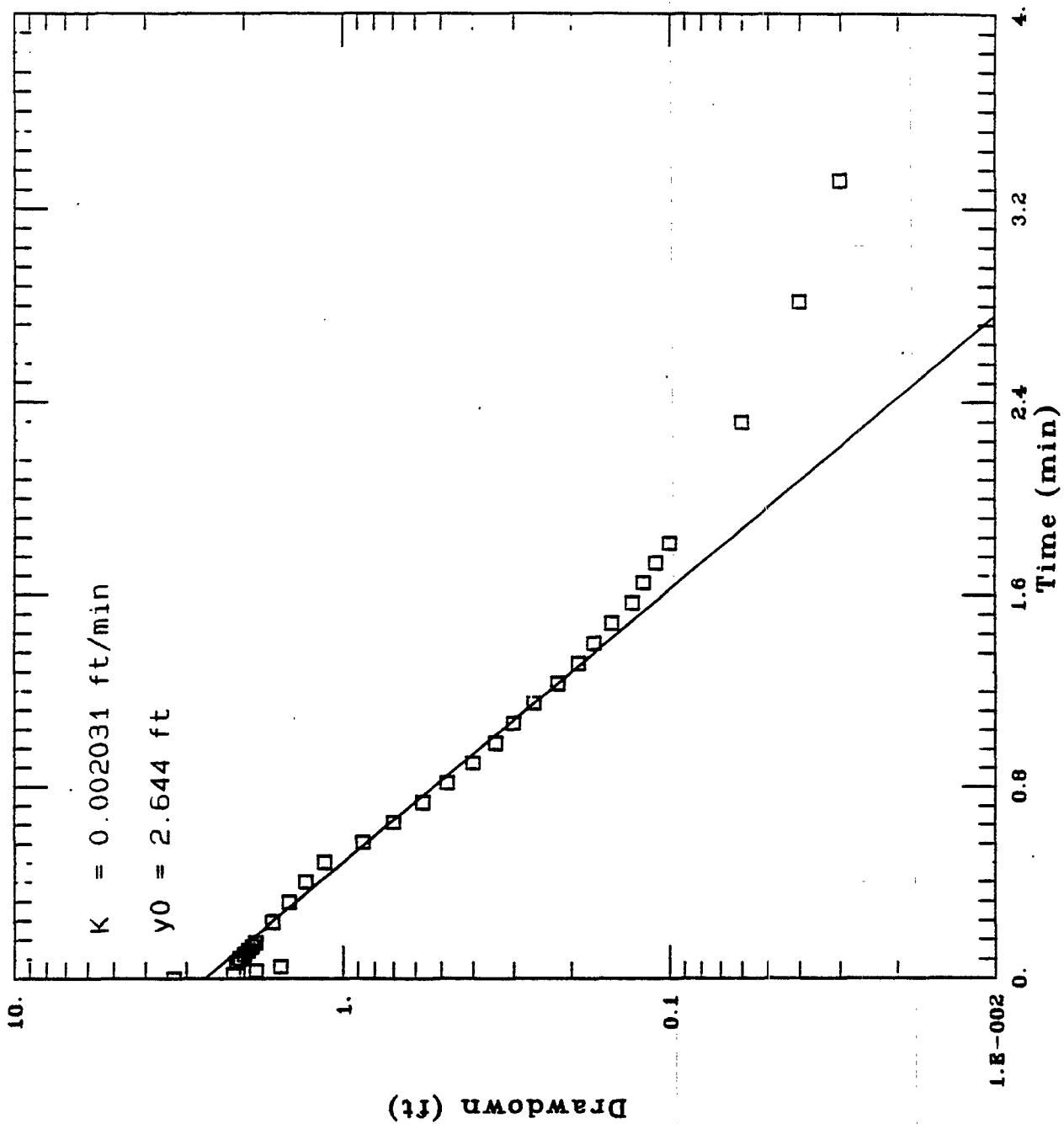
AR301682

# Rising Head Slug Test: MW-2



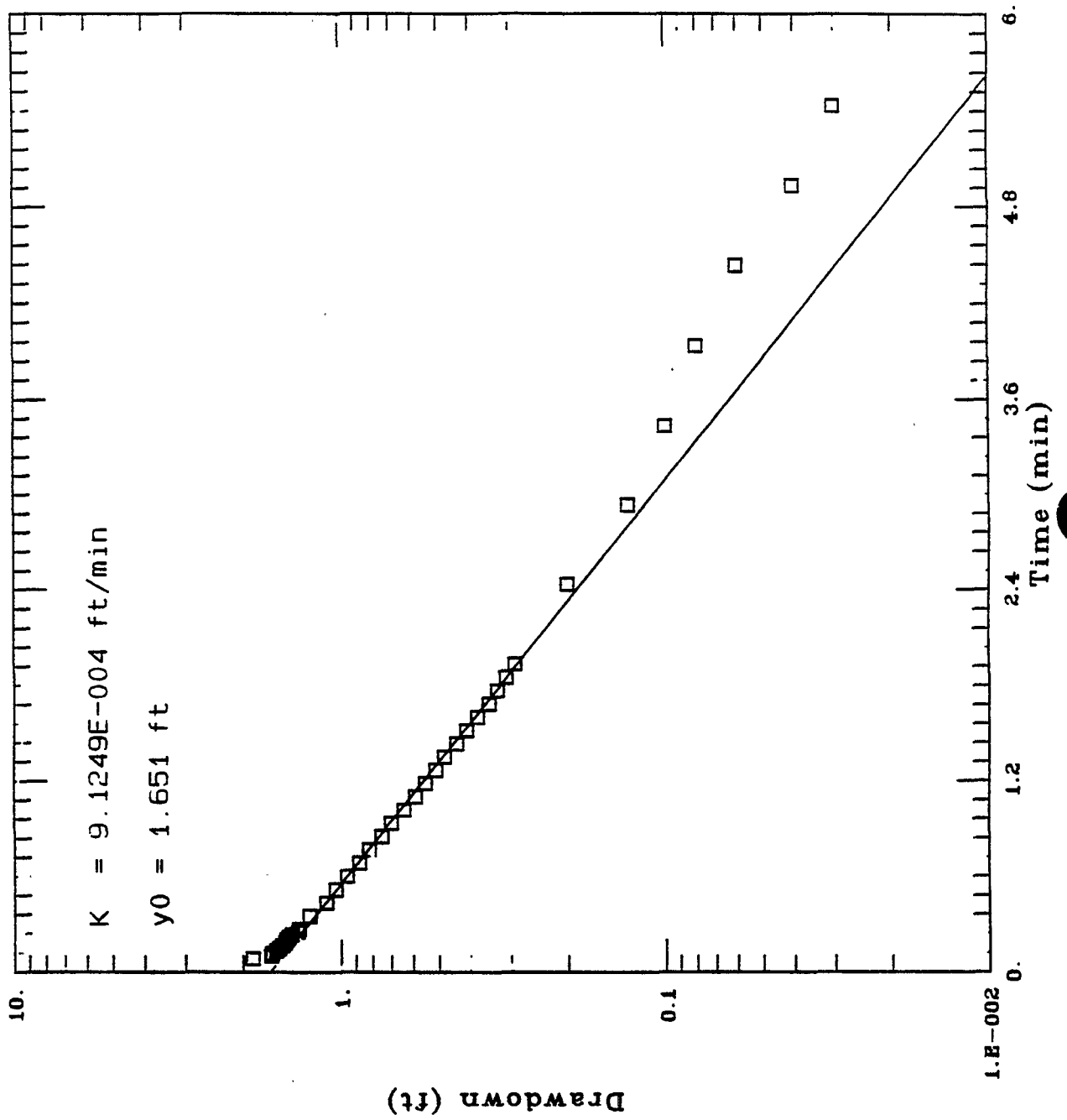
AR301683

# Falling Head Slug Test: MW-3



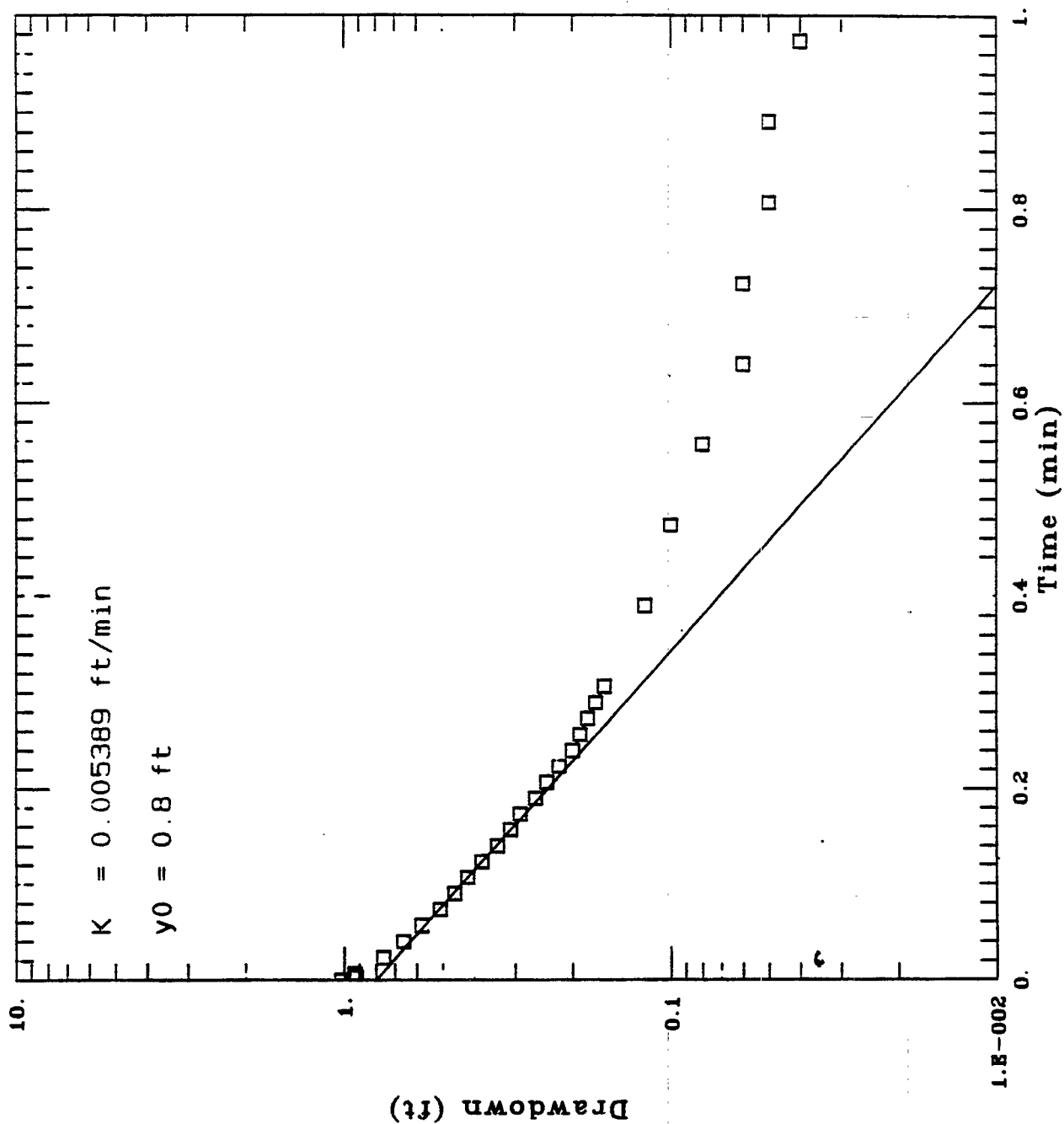
AR301684

# Rising Head Slug Test: MW-3



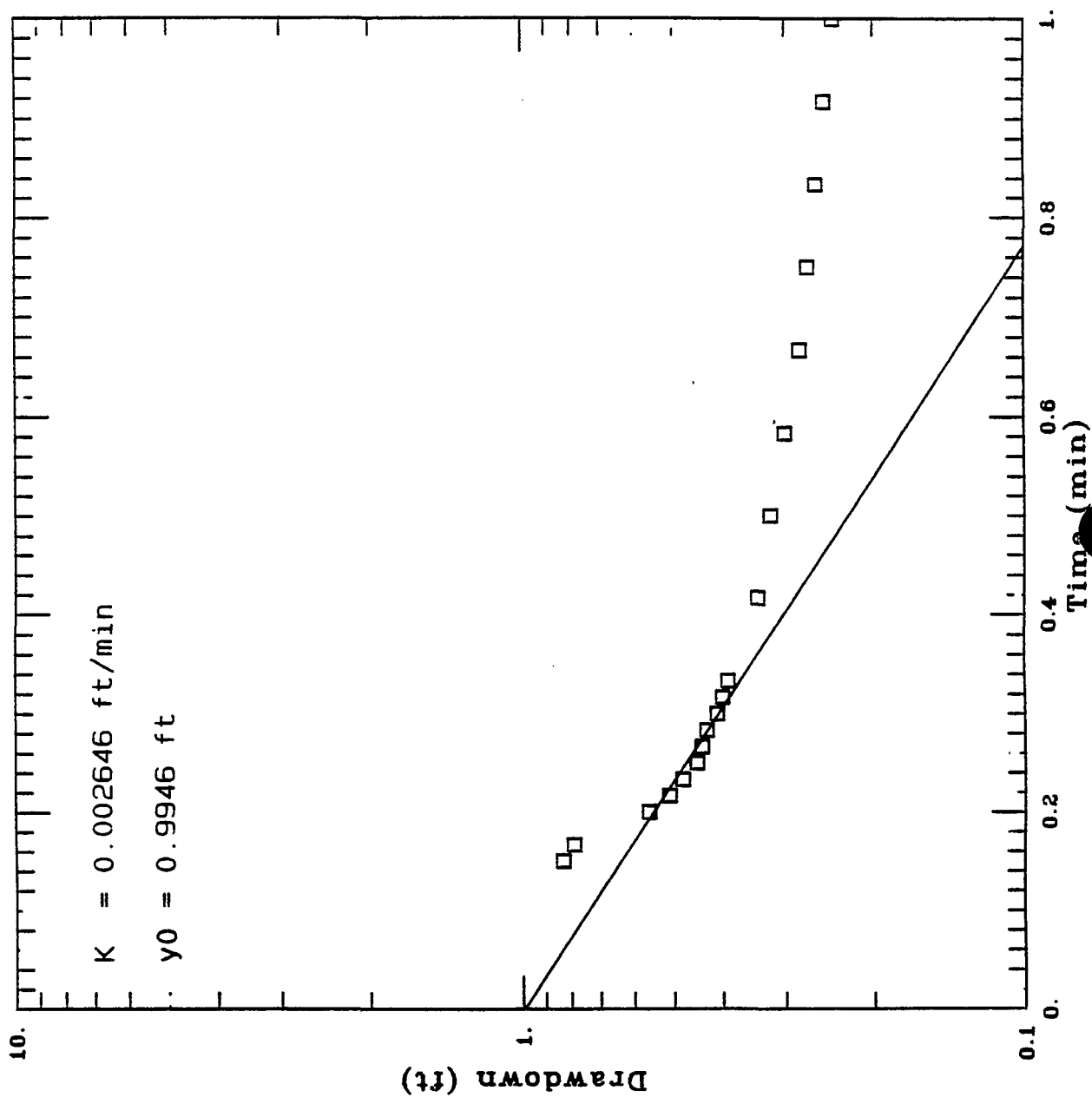
AR301685

# Falling Head Slug Test: MW-4



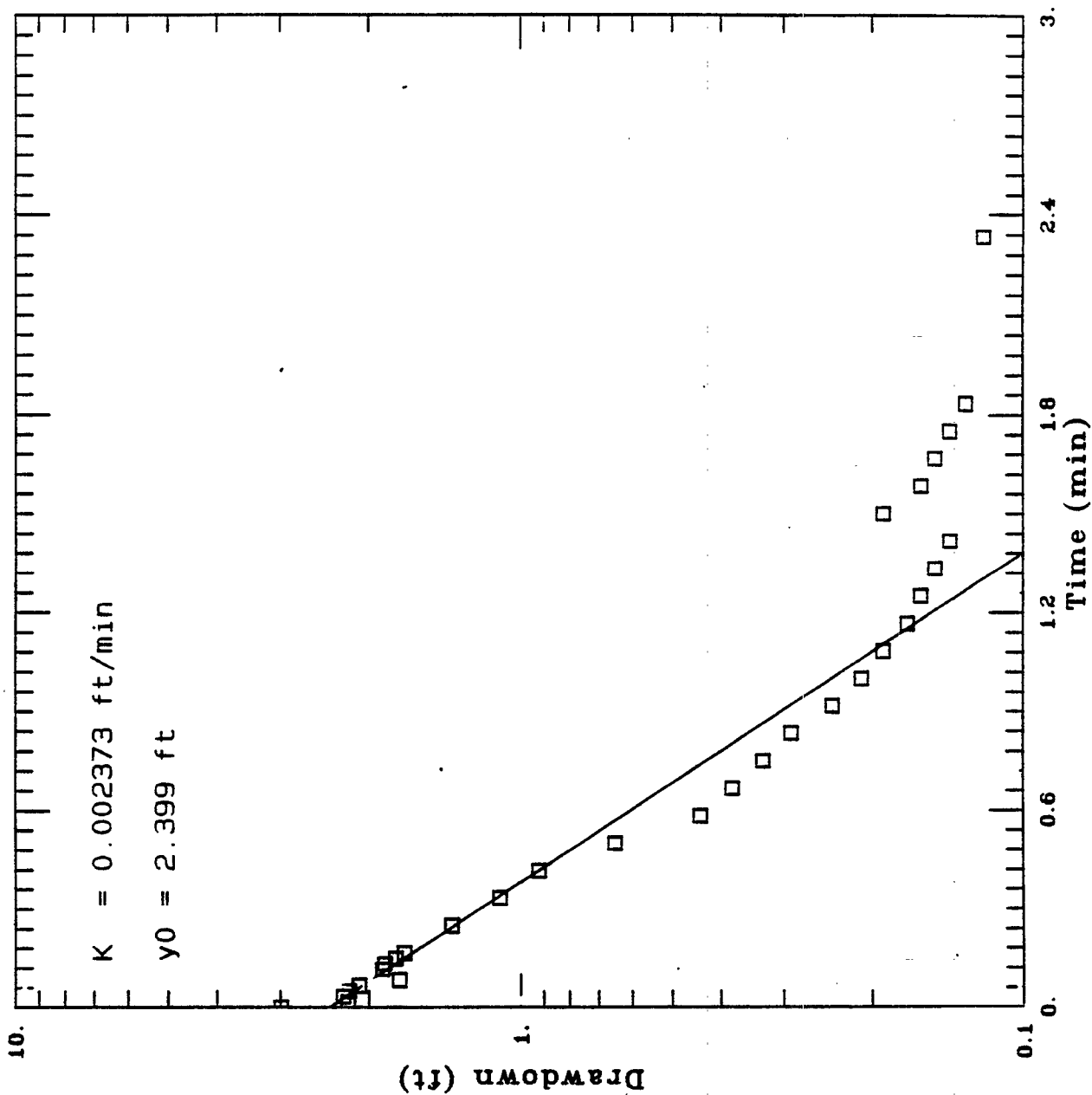
AR301686

# Rising Head Slug Test: MW-4



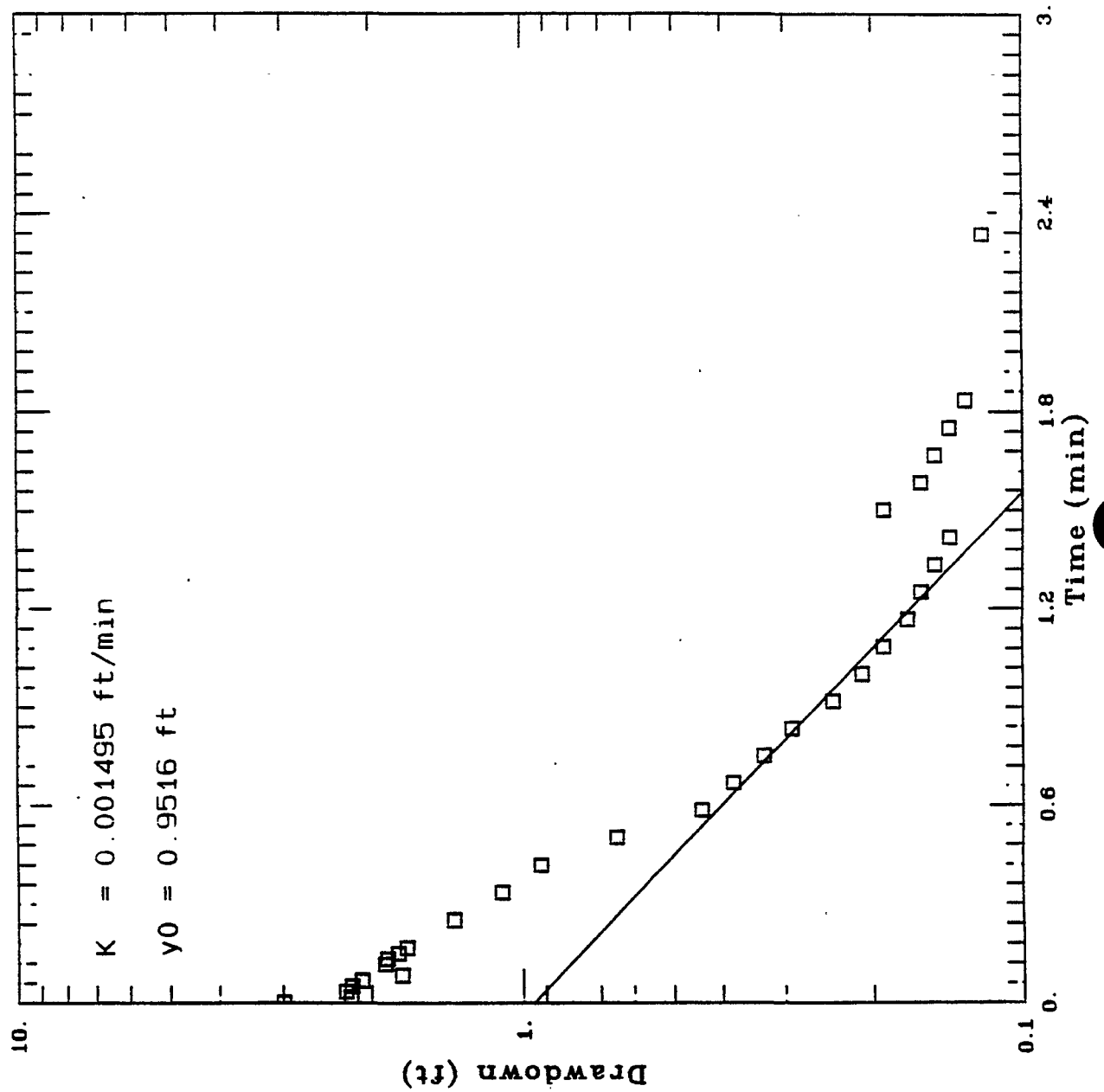
AR301687

# Falling Head Slug Test: MW-5



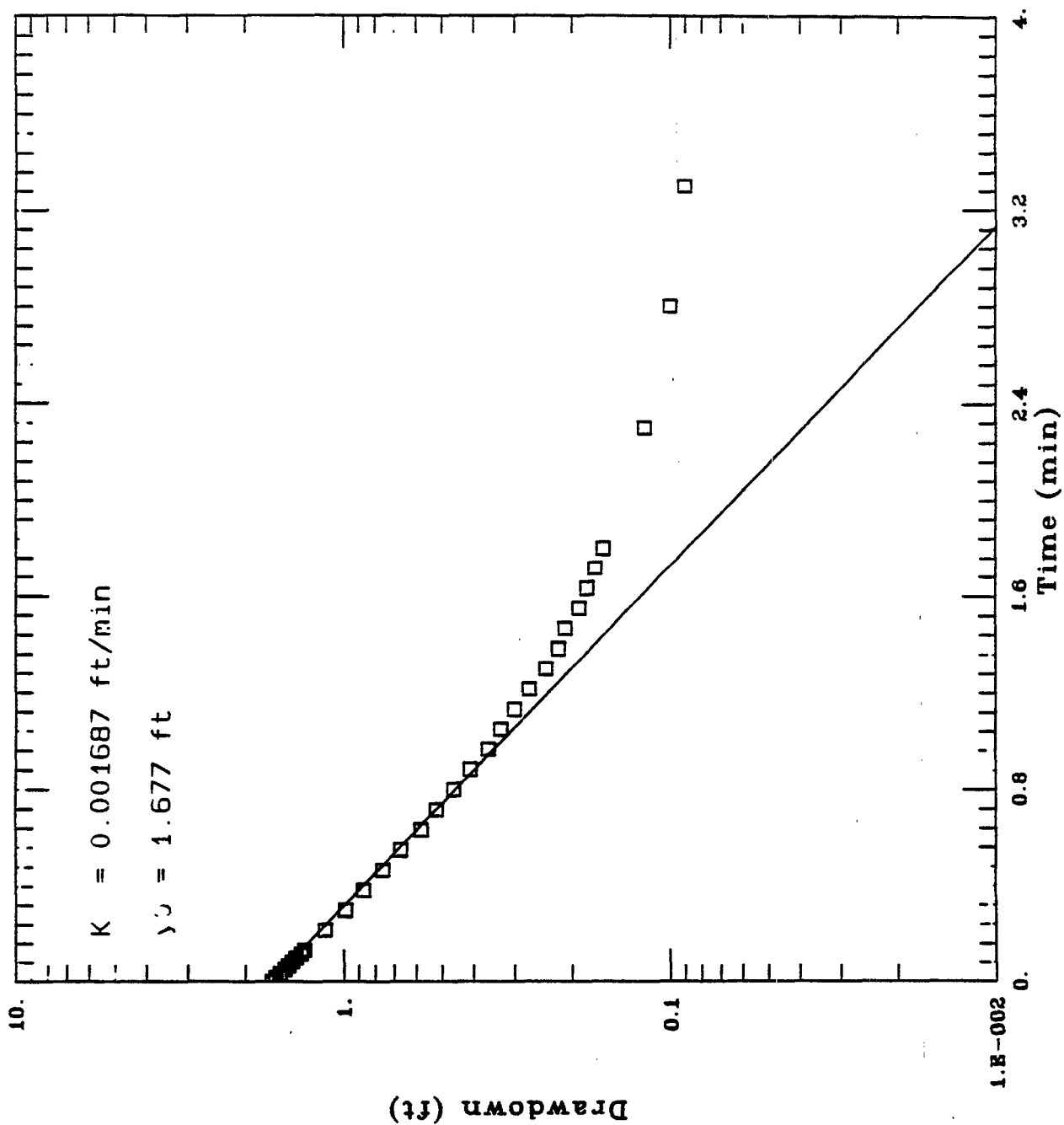
AR301688

# Falling Head Slug Test: MW-5



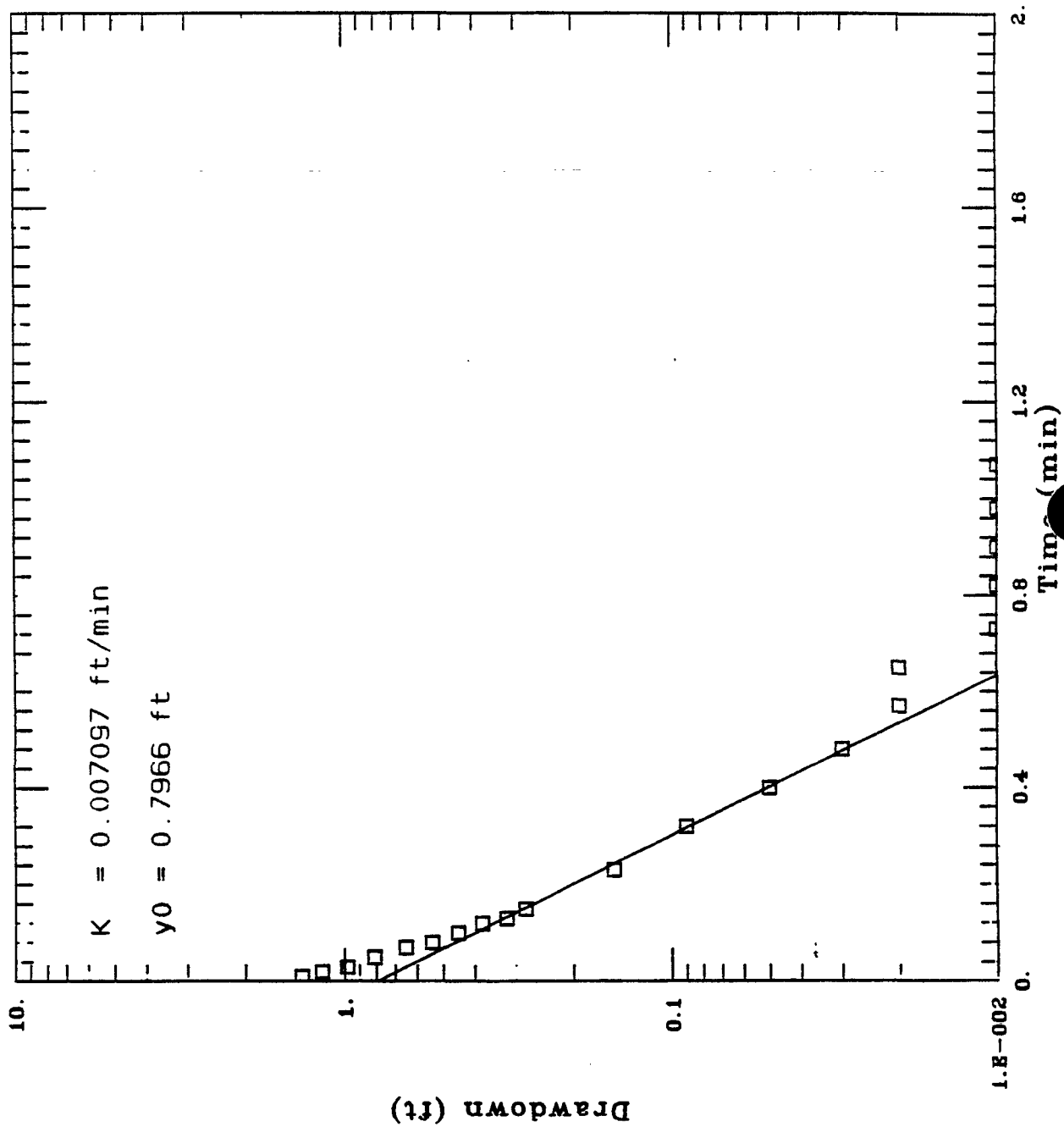
AR301689

# Rising Head Slug Test: MW-5



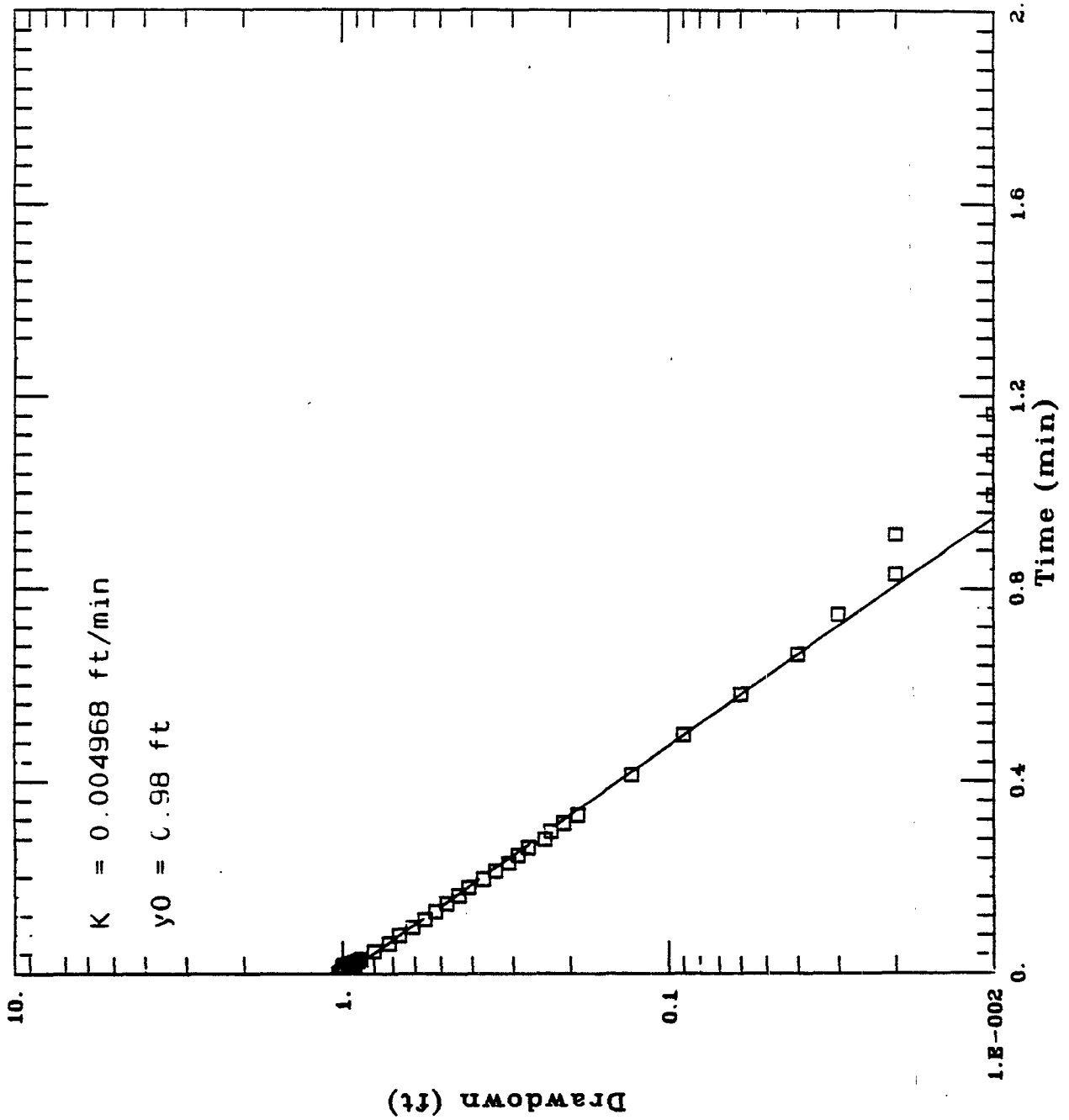
AR301690

# Falling Head Slug Test: MW-6



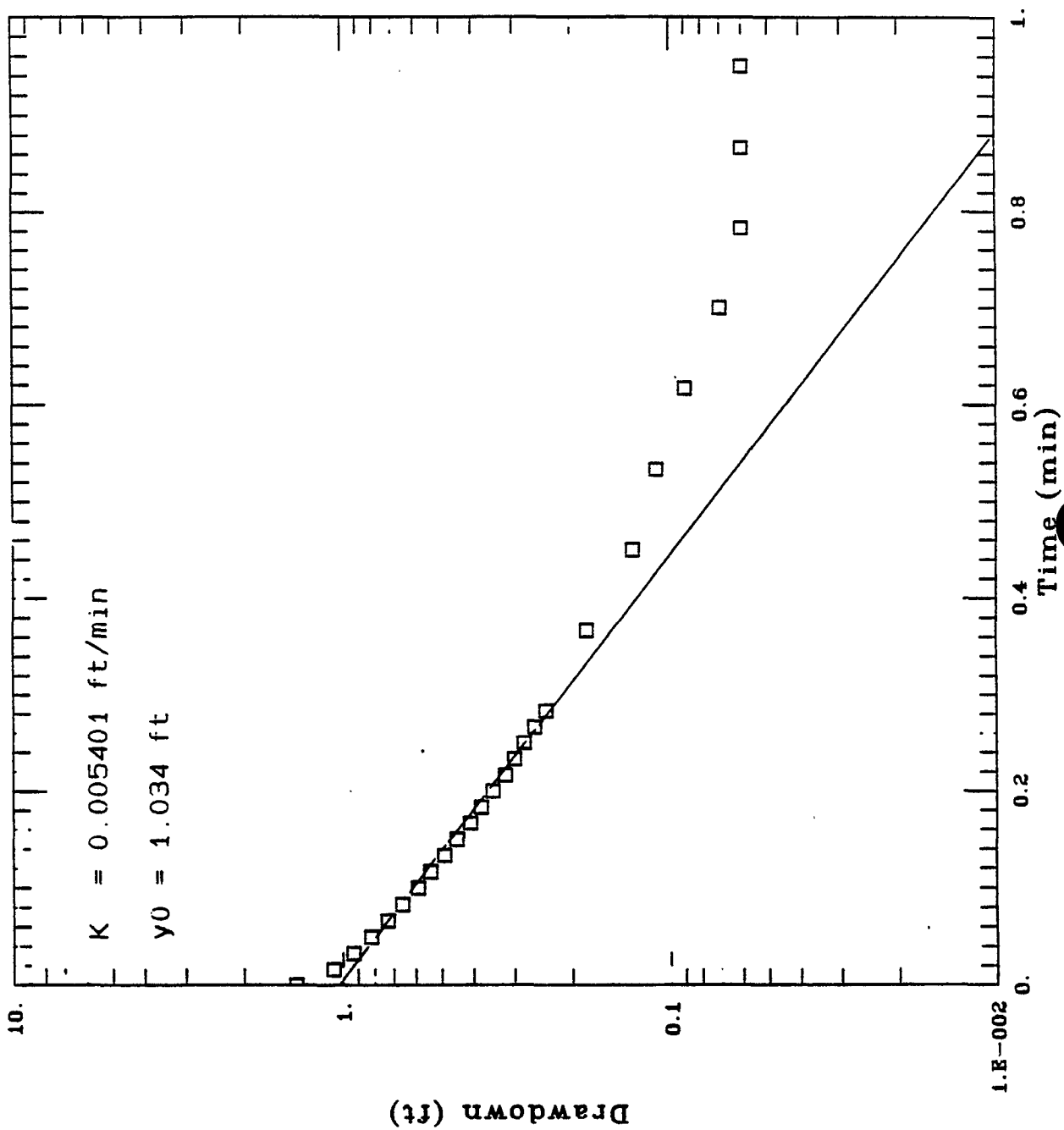
AR301691

# Rising Head Slug Test: MW-6



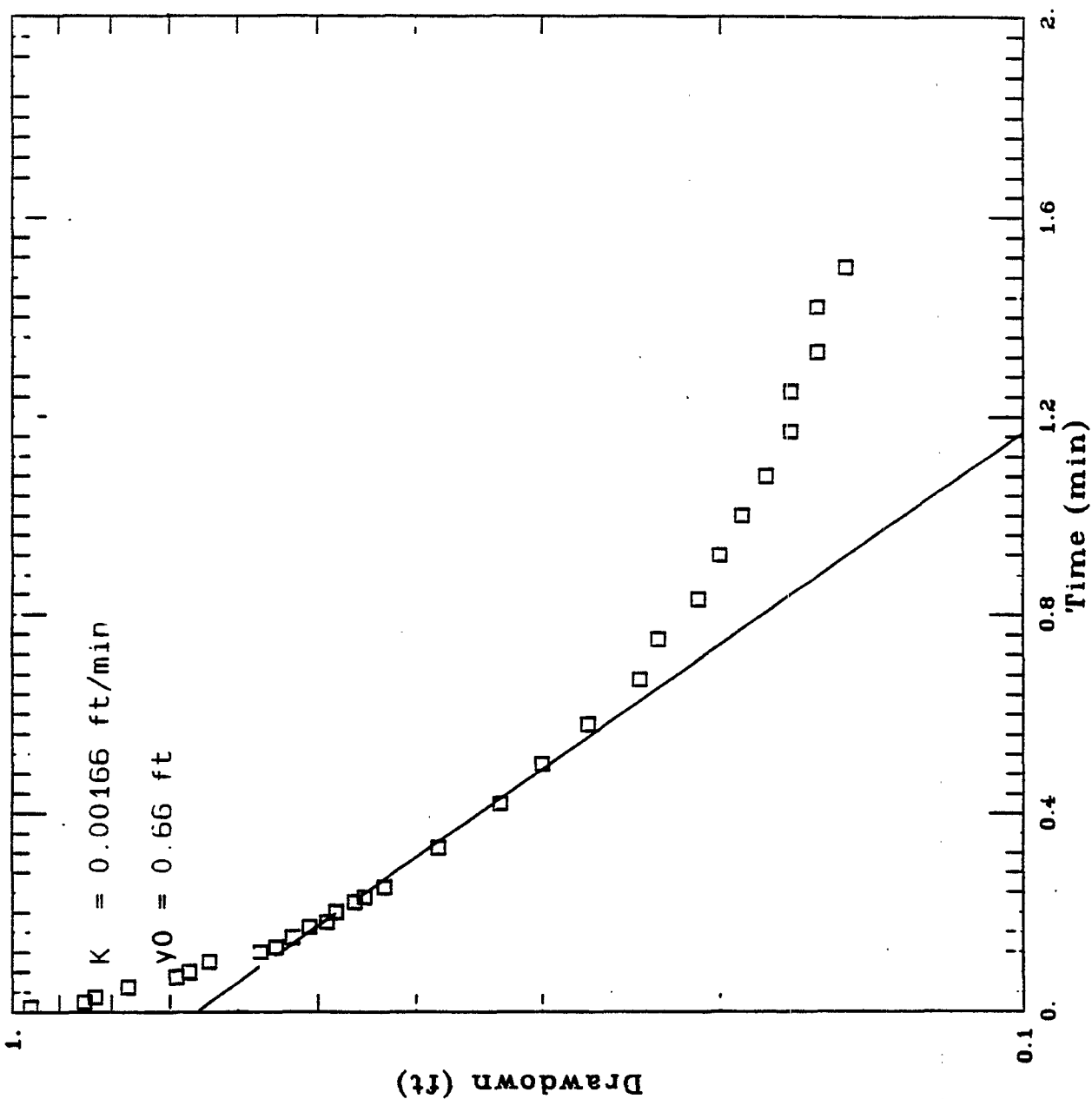
AR301692

# Falling Head Slug Test: MW-7



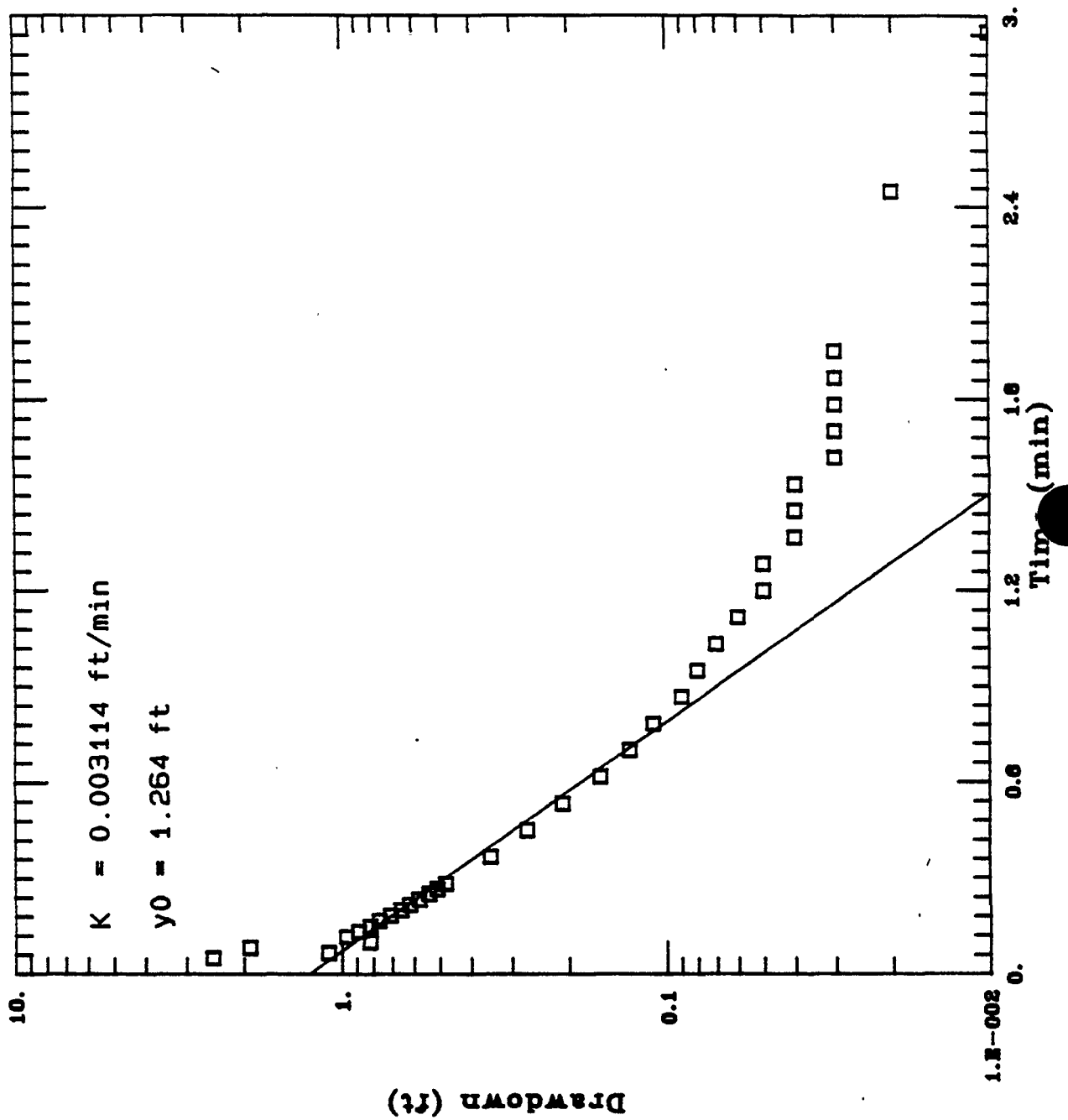
AR301693

# Rising Head Slug Test: MW-7



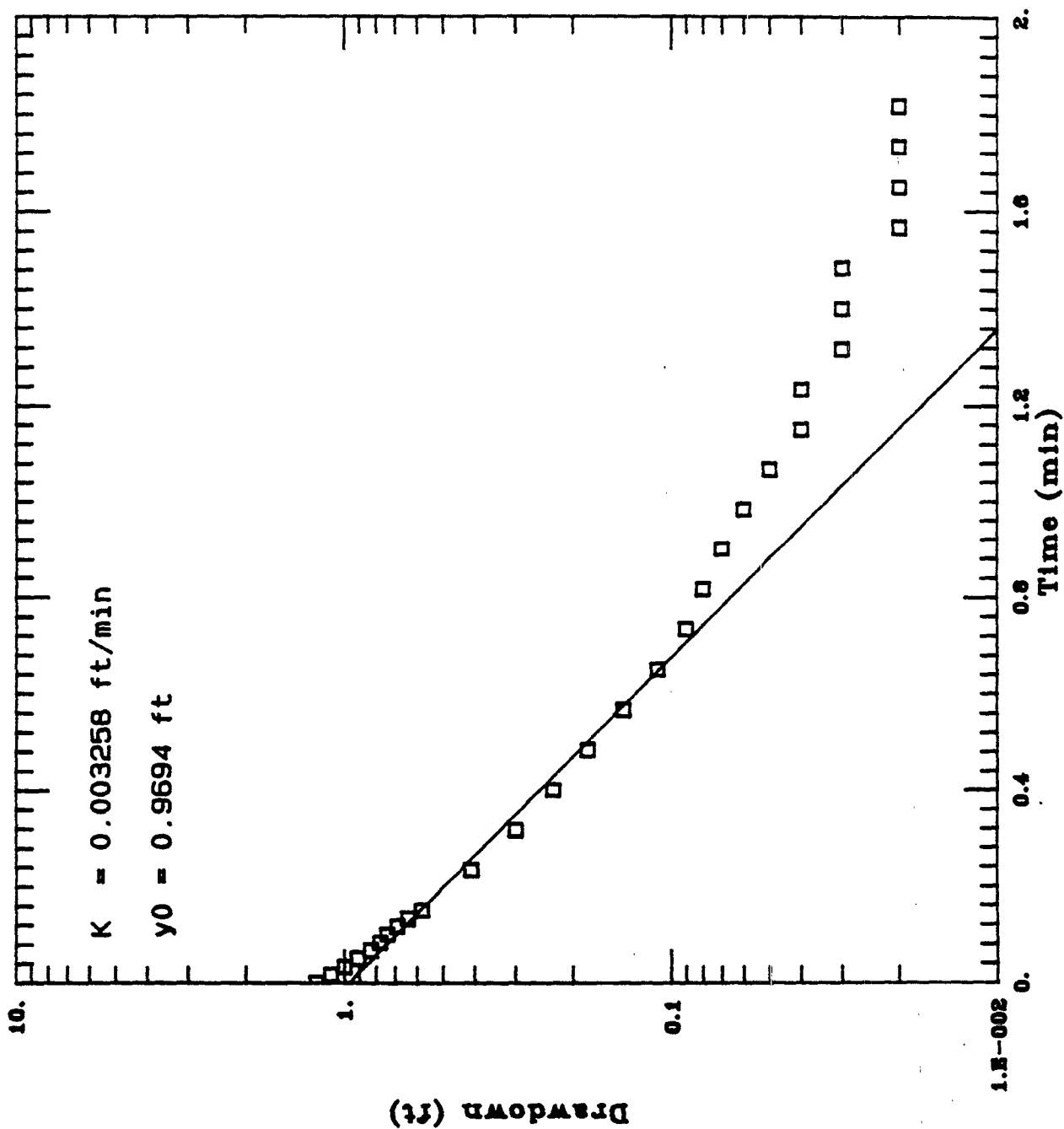
AR301694

# Falling Head Slug Test: MW-9



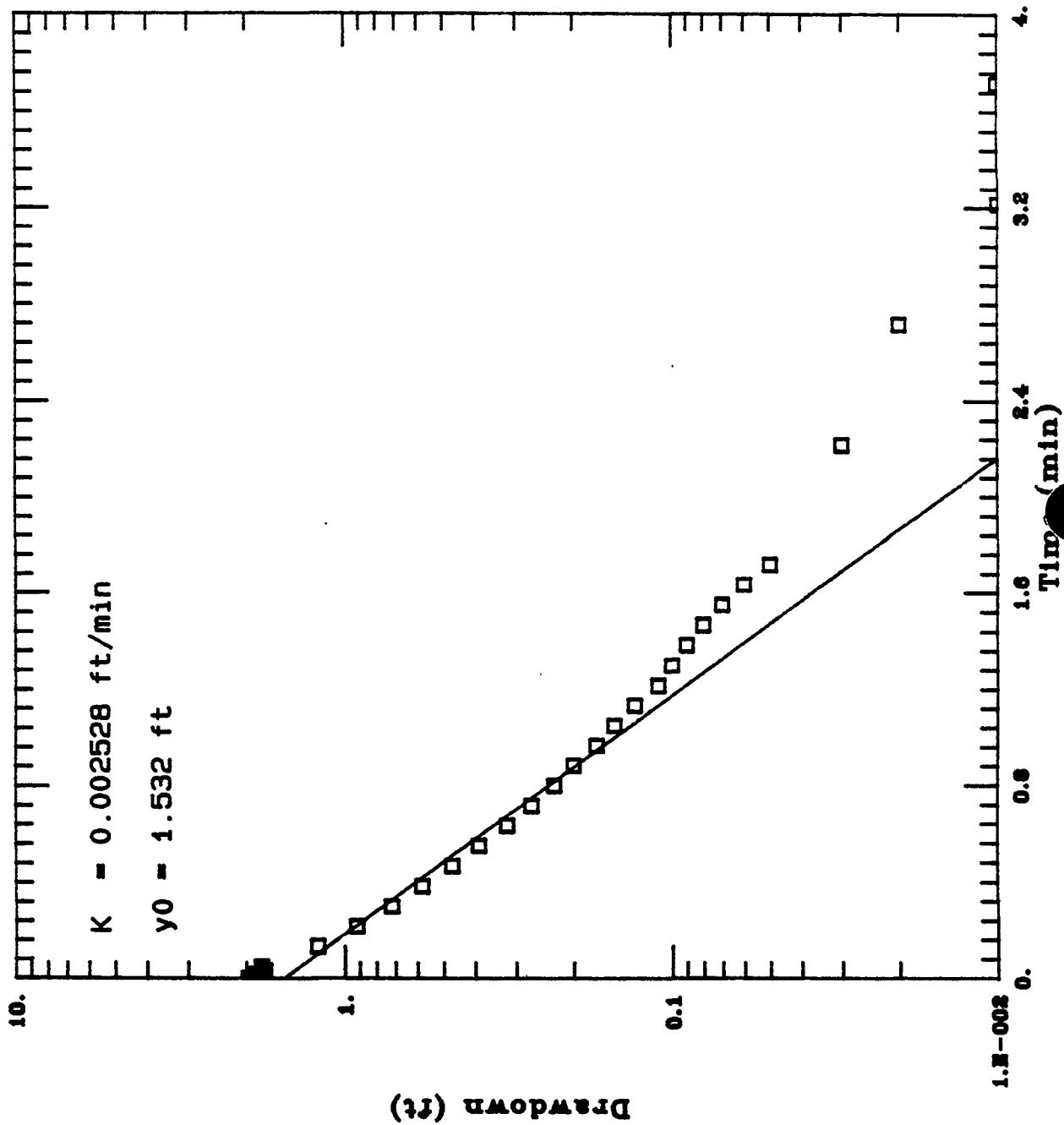
AR301695

# Rising Head Slug Test: MW-9



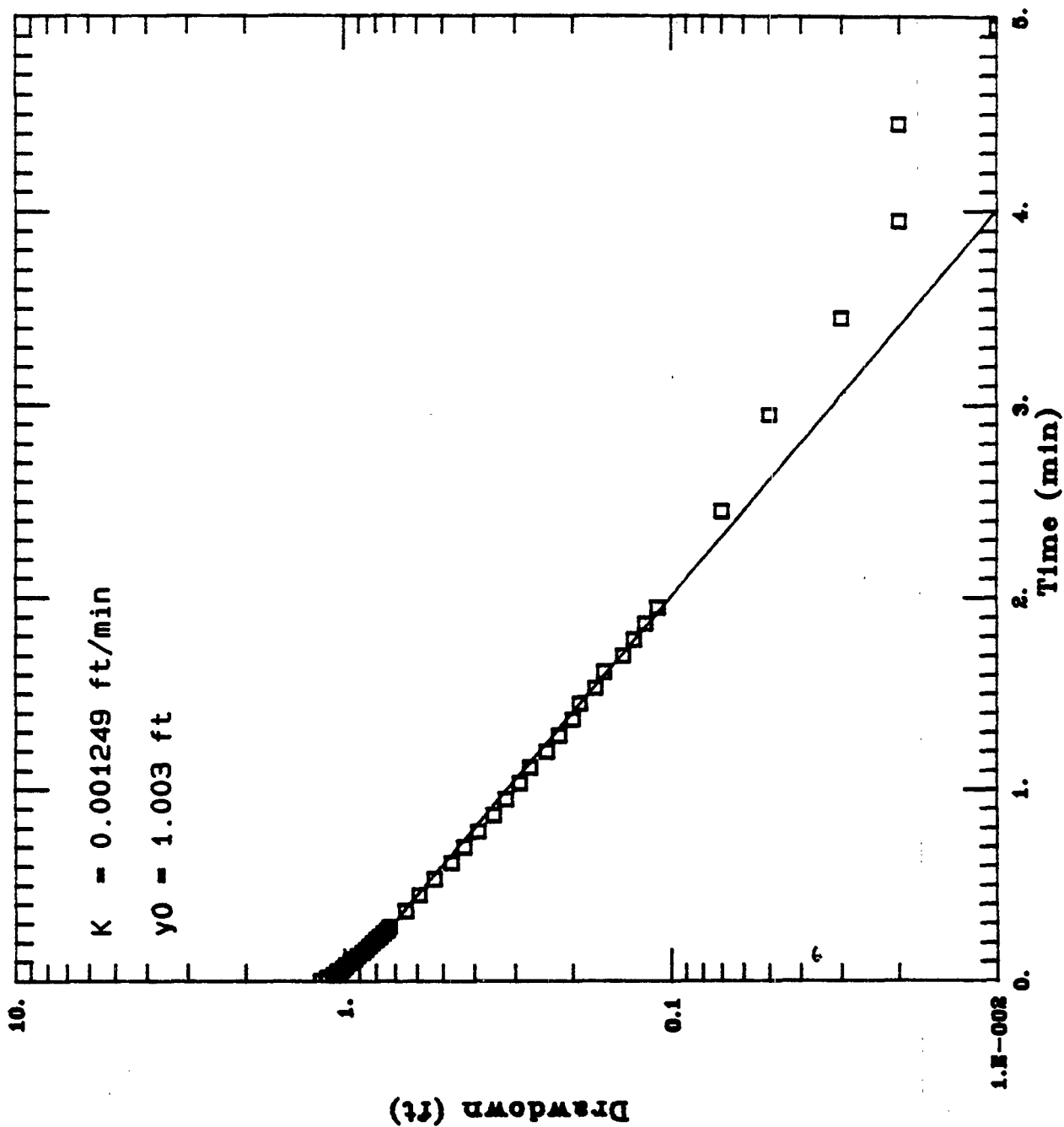
AR301696

# Falling Head Slug Test: MW-10



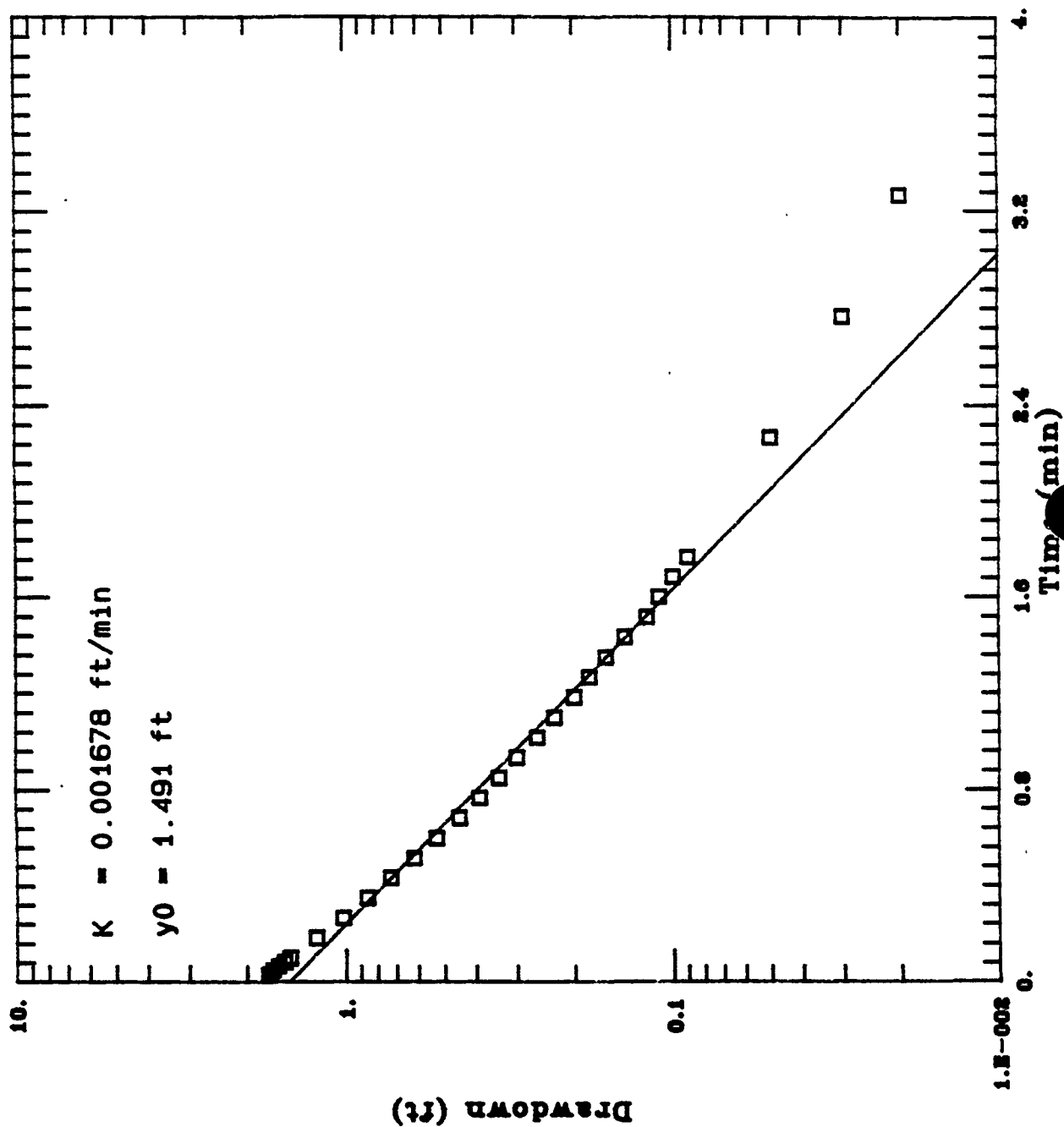
AR301697

# Rising Head Slug Test: MW-10



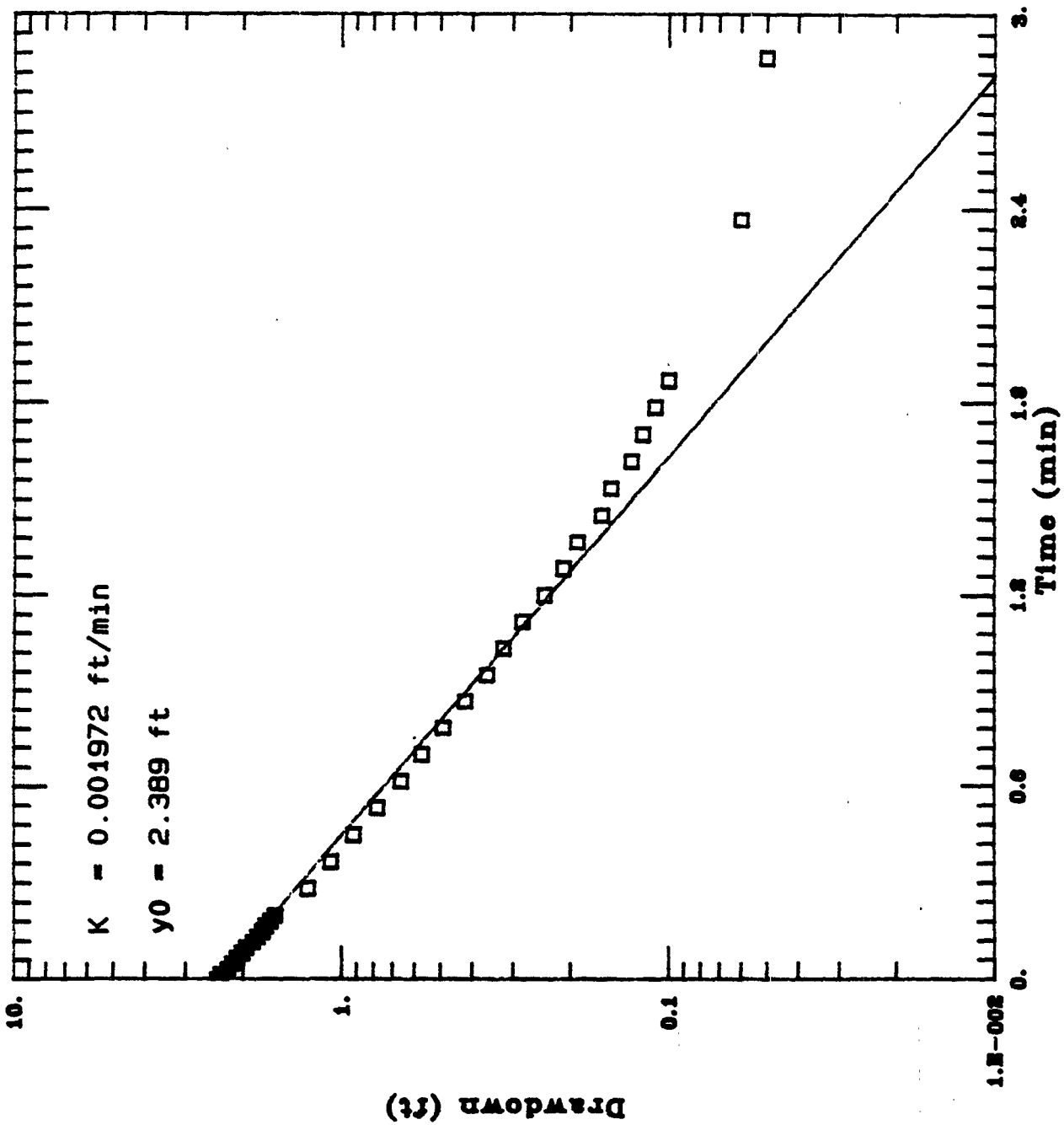
AR301698

# Falling Head Slug Test: MW-11



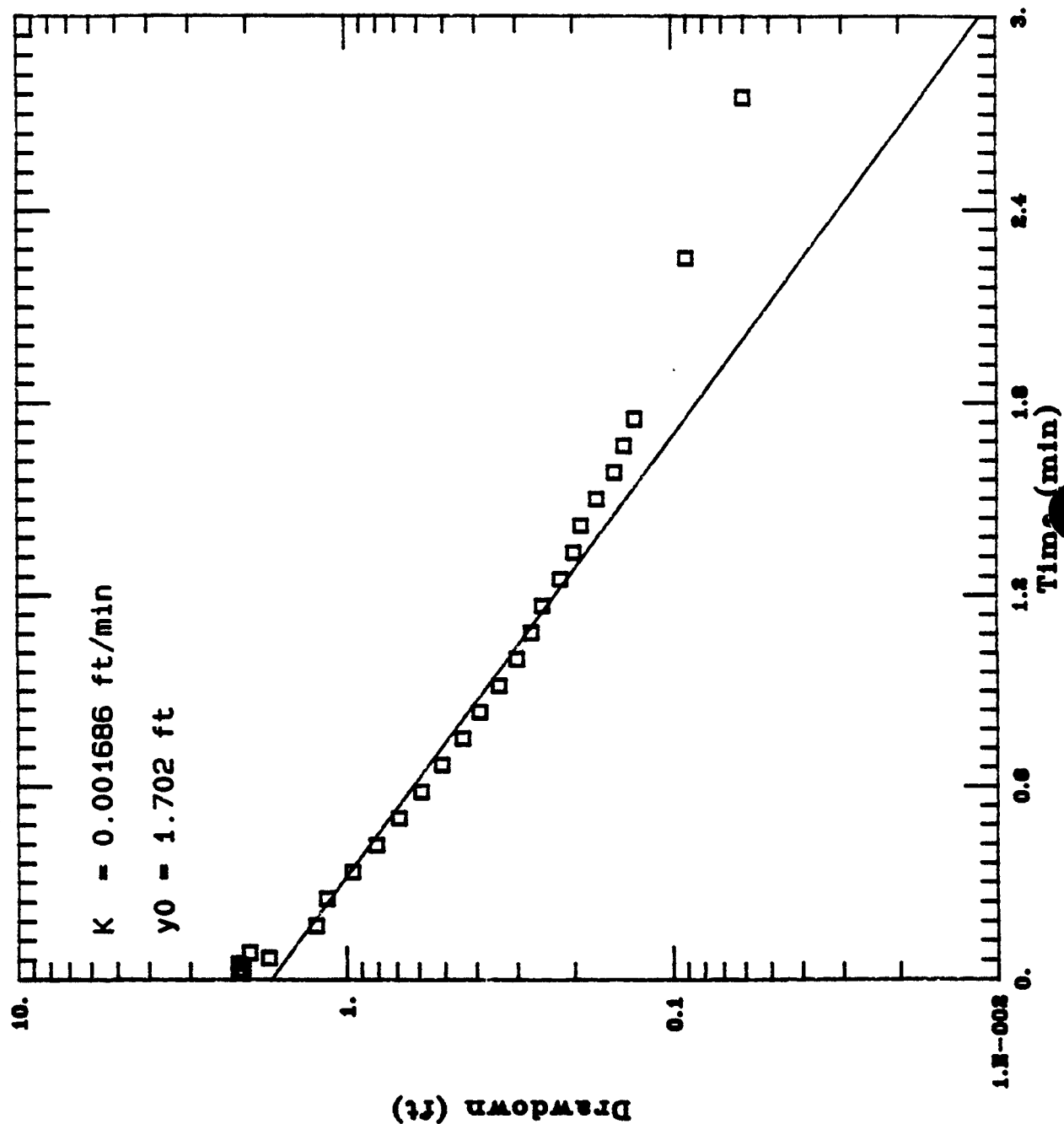
AR301699

# Rising Head Slug Test: MW-11



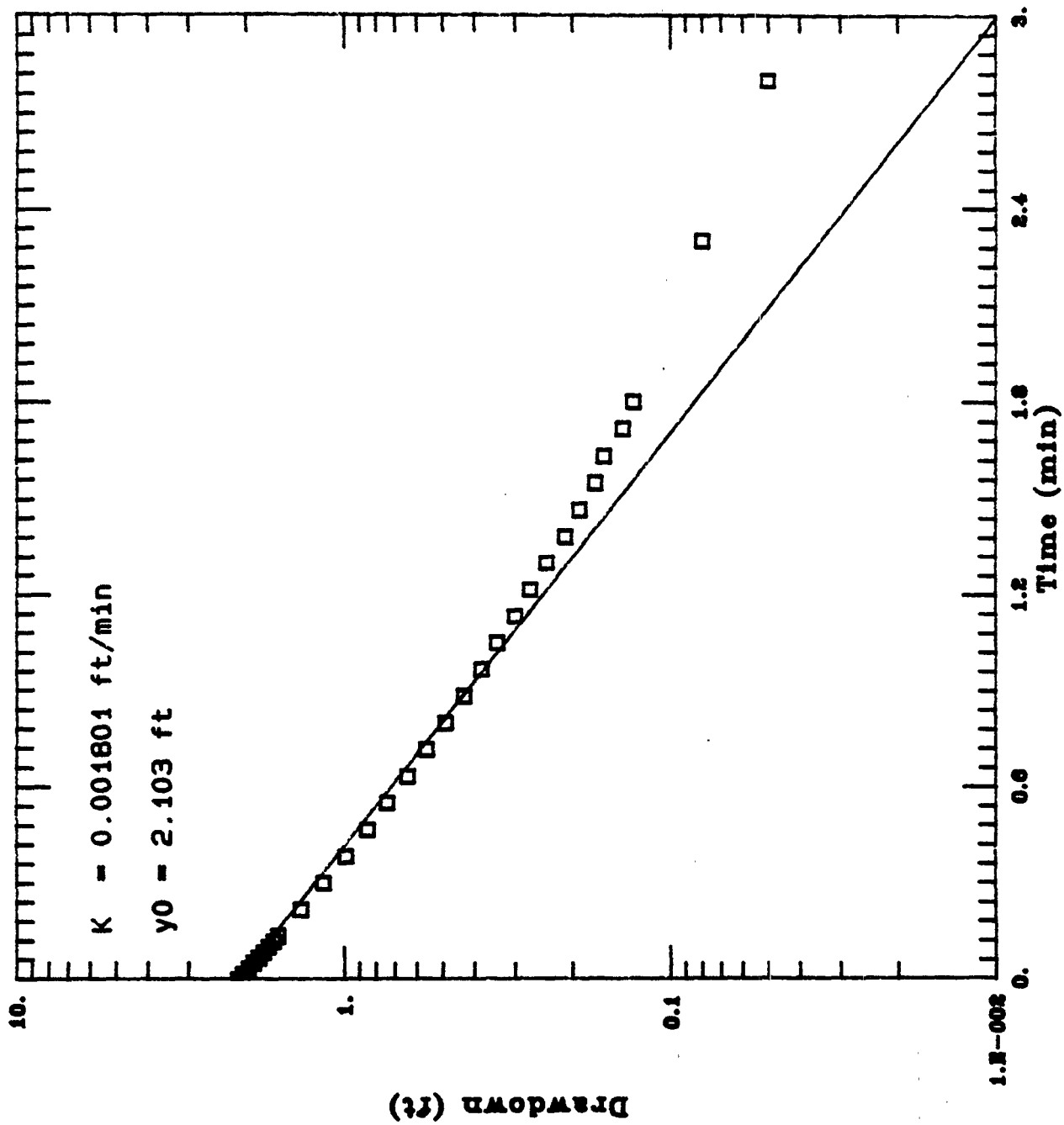
AR301700

# Falling Head Slug Test: MW-12



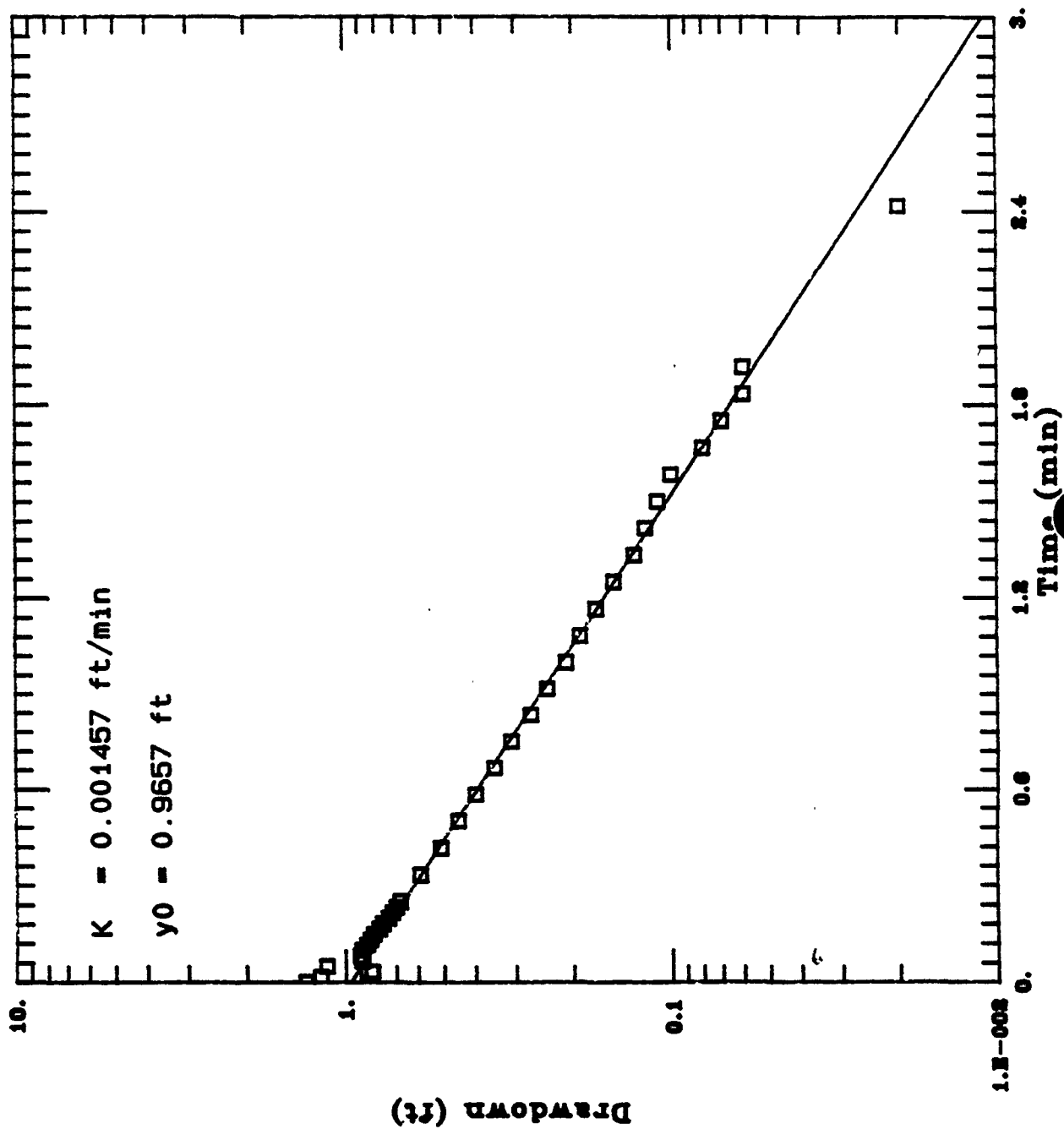
AR301701

# Rising Head Slug Test: MW-12



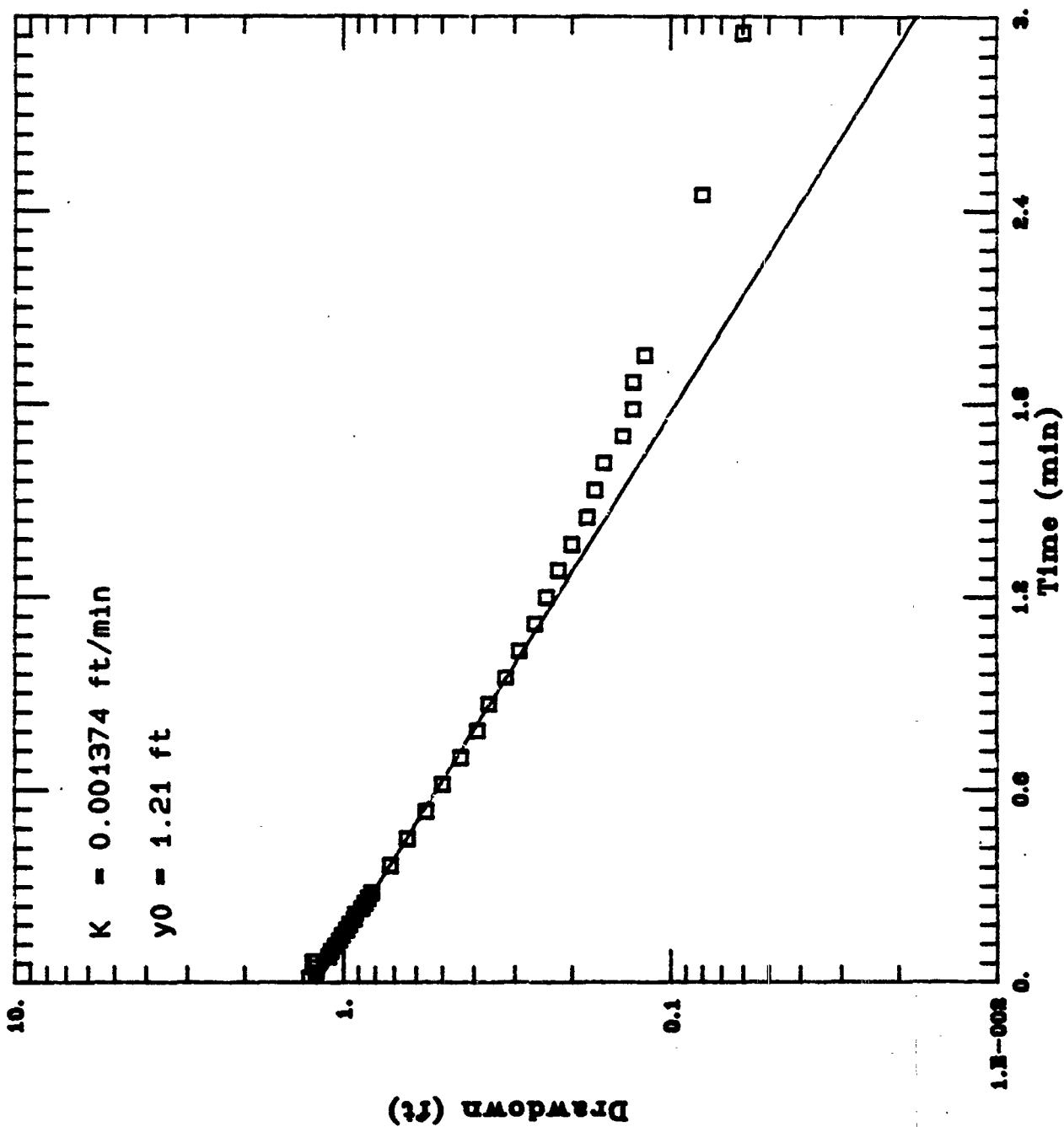
AR301702

# Falling Head Slug Test: MW-13



AR301703

# Rising Head Slug Test: MW-13



AR301704

**APPENDIX F**  
**LABORATORY DATA**

**(Validated Data Summary Tables and  
Validation Reports)**

**AR301705**

**GROUND WATER**

**AR301706**

ROWHEAD PLATING SITE  
VOLATILE ORGANICS DATA FOR GROUND WATER (Round 1)  
in units of ug/L

Sample ID	Acetone	2-Butanone	1,1-Dichloroethene	1,2-Dichloroethene	1,1,1-Trichloroethene	Trichloroethene	Tetrachloroethene	Methylene Chloride	1,1-Dichloroethane	Comment
Federal Standards ug/L	NA	NA	7(f)	270(h)	200(f)	5(f)	5(g)	150(h)	NA	
PM1-GW1	190(e)	100(b)	25 U	25 U	25 U	25 U	25 U	25 U	25 U	Note A
PM2-GW1RE	10 U	10 U	5 U	5 U	5 U	120(a)	5 U	5 U	5 U	Note B
PM3-GW1RE	10 U	10 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	Note B
PM4-GW1	10 U	10 U	5 U	5 U	5 U	5 U	5 U	(5)	5 U	
PM5-GW1RE	10 U	10 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	Note B
PM6-GW1RE	10 U	10 U	5 U	5 U	5 U	5 U	17(a)	5 U	5 U	Note B
PM7-GW1	10 U	10 U	4(c)	4 U	4(c)	9	48	5 U	5 U	Note C
PM8-GW1	1,300(e)	1,000 U	710	500 U	620	1,100	8,200	500 U	500 U	Note A
PM9-GW1DL	20,000 U	20,000 U	9,900(d,a)	10,000 U	150,000(a)	10,000 U	26,000(a)	(14,000)	10,000 U	Note B
PM9-GW1ADL (Dup)	20,000 U	20,000 U	9,800(d,a)	10,000 U	140,000(a)	10,000 U	26,000(a)	(15,000)	10,000 U	Note B
PM10-GW1RE	1,000 U	1,000 U	1,300(a)	500 U	1,900(a)	4,200(a)	12,000(a)	(700)	500 U	Note B
PM11-GW1	50 U	50 U	280	33	320	480	8,000	(30)	42	Note D
PM12-GW1RE	1,000 U	1,000 U	390(d)	500 U	520(a)	980(a)	16,000(a)	(470)	500 U	Note B
PM13-GW1RE	1,000 U	1,000 U	500 U	560(a)	320(a,d)	1,300(a)	12,000(a)	(430)	500 U	Note B
AR1-GW1	10 U	10 U	5 U	5 U	5 U	3(c)	19(b)	5 U	5 U	
AR2-GW1	200 U	200 U	200(b)	100 U	260	990(b)	880(b)	100 U	100 U	
AR2-GW1A	200 U	200 U	280(b)	100 U	350	1,300(b)	1,200(b)	100 U	100 U	
AR3-GW1	500 U	500 U	250 U	4,400	900	4,200	4,300(e)	180(d)	250 U	

NA=Not Available  
DL=Dilution

extraction

indicates compound was not detected above the limit indicated.  
This detected concentration is considered non-detected because it is within ten times the concentration detected in the reagent blank.  
Due to laboratory data recording problems the original analysis is not usable.  
The reanalysis exceeded the holding time; therefore, the value is considered estimated.  
The compound is tentatively identified.

The compound is tentatively identified and quantitated at less than the method detection limit.  
Mass spectral data suggests the presence of this compound, but due to the dilution the compound cannot be confirmed.  
Due to a substantial deviation in the response for the daily calibration, this value is considered estimated.

40 CFR, Part 141-National Primary Drinking Water Regulation. pp526-533, 585-587

Proposed

Suggested No Adverse Response Levels (SNARLS)

- e A: Non-detected data for Carbon Disulfide, Vinyl Acetate, 4-Methyl-2-pentanone, and 2-Hexanone should be rejected.
- e B: As a result of not meeting holding time, the method quantitation limits are considered estimated for all target compounds.
- e C: Non-detect data for Acetone, Carbon Disulfide, Vinyl Acetate, 4-Methyl-2-pentanone, and 2-Hexanone should be rejected.
- e D: The value for Tetrachloroethene was determined from a dilution.

AR301707

ARROWHEAD PLATING SITE  
VOLATILE ORGANICS ANALYSIS DATA FOR GROUND WATER (Round 2)  
in units of ug/L

Sample ID	1,1-Dichloroethene	1,1,1-Trichloroethene	Trichloroethene	Tetrachloroethene	Carbon Disulfide	Methylene Chloride	Chloroform	Acetone
Federal Standards	7(f)	200(f)	5 (f)	5 (g)	NA	150(i)	NA(h)	NA
MW1-GW2	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
MW2-GW2	5	5	94	5 U	39	5 U	5 U	5 U
MW3-GW2	5 U	5 U	5 U	5 U	5 U	5	5 U	5 U
MW4-GW2	5 U	5 U	5 U	5 U	5 U	4(c)	5 U	18
MW5-GW2	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
MW6-GW2	5 U	5 U	5 U	22	5 U	5 U	5 U	5 U
MW7-GW2	10 U	10 U	6 (c)	110	10 U	10 U	17	10 U
MW8-GW2	510	530	800	5,400	500 U	500 U	500 U	500 U
MW9-GW2	2,600	36,000	2,500 U	6,800	2,500 U	2,500 U	2,500 U	2,500 U
MW10-GW2	1,900 (d)	5,200	4,700	14,000	2,500 U	2,500 U	2,500 U	2,500 U
MW11-GW2	260 (b)	310	560 (b)	6,800 (b)	250 U	200(d)	250 U	600
MW12-GW2	1,000 U	600 (d)	700 (d)	7,700	1,000 U	1,000 U	1,000 U	1,000 U
MW13-GW2	1,000 U	1,000 U	670 (d)	5,800	1,000 U	1,000 U	1,000 U	1,000 U

U indicates that compound was not detected above the limit indicated.

NA = Not Available

(b)=The compound is tentatively identified.

(c)=The compound is tentatively identified and quantitated at less than the method detection limit.

(d)=Mass spectral data suggests the presence of this compound, but due to the dilution the compound cannot be confirmed.

(f)=40 CFR, Part 141-National Primary Drinking Water Regulation. pp526-533, 585-587

(g)=Proposed

(h)=A Maximum Contaminant Level has been established for total trihalomethanes at 0.10 mg/l (which includes chloroform).

(i)=Suggested No Adverse Response Levels (SNARLS)

01/25/91

AR301708



ARROWHEAD PLATING SITE  
SEMIVOLATILE ORGANICS DATA FOR GROUND WATER (Round 1)  
in units of ug/L

Sample ID	Target Compound List Detected	Number of Tentatively Identified Compounds	Tentative Identifications	Comments
M41-GW1	ND	0		
M42-GW1	ND	0		
M43-GW1	ND	1	2-Cyclohexen-1-one	
M44-GW1	ND	0		
M45-GW1	ND	1	2-Cyclohexen-1-one	
M46-GW1	ND	0		
M47-GW1	ND	6	Tetrachloroethene, Cyclic Compounds, Phosphoric Acid Ester, and Unknowns	
M48-GW1	ND	12	Tetrachloroethene, Substituted 2-Propanols, Organosulfur Compounds, and Unknowns	
M49-GW1	ND	15	Tetrachloroethene, Sub. 2-Propanol, Unknown Hydrocarbons, and Unknowns	
M49-GW1A	ND	14	Tetrachloroethene, Unknown Hydrocarbons, and Unknowns	
M410-GW1	ND	10	Tetrachloroethene, Substituted 2-Propanols, Organosulfur Compounds, and Unknowns	Note A
M411-GW1	ND	6	Substituted 2-Propanol, 1H-Benzotriazole, and Unknowns	Note B
M412-GW1	ND	6	Tetrachloroethene, Substituted 2-Propanol, and Unknowns	
M413-GW1	ND	10	Tetrachloroethene and Unknowns	
AR1-GW1	ND	0		
AR2-GW1	ND	0		
AR2-GW1A	ND	1	Unknown Substituted Benzene	
AR3-GW1	ND	0		

ND-No target compounds detected  
Note: Due to the recovery of an acid surrogate at less than 10% for this sample, non-detect data for the acid fraction should be rejected.  
Note: No surrogate compounds detected; all non-detect data should be rejected.

01/25/91

301710

ARROWHEAD PLATING SITE  
SEMIVOLATILE ORGANICS DATA FOR GROUND WATER (Round 2)  
in units of ug/L

Sample ID	Target Compound List Detected	Number of Tentatively Identified Compounds	Tentative Identifications	Comments
M41-GW2	ND	0		
M42-GW2	ND	0		
M43-GW2	ND	2	Dodecanamide and Unknown	
M44-GW2	ND	0		
M45-GW2	ND	0		
M46-GW2	ND	0		
M47-GW2	ND	2	Phosphoric Acid Ester and Unknown Substituted Benzene	
M48-GW2	ND	2	Substituted 2-Propanols and Unknowns	Note A
M49-GW2	ND	2	Unknowns	
M410-GW2	ND	5	Substituted 2-Propanols and Unknowns	
M411-GW2RE	ND	4	Tetrachloroethene, Substituted Propanol, Substituted Benzene, and Unknown	Note B
M412-GW2	ND	4	Substituted 2-Propanols, Unknown, and Unknown Substituted Benzene	
M413-GW2	ND	7	Unknown and Unknown Substituted Benzene	

ND-No target compounds detected

RE-Reextraction

Note A: Due to the recovery of an acid surrogate at less than 10% for this sample, non-detect data for the acid fraction should be rejected.

Note B: Due to exceeding holding time, method detection limits should be considered estimated.

01/25/91

AR301711

ARROWHEAD PLATING SITE  
INORGANIC DATA FOR GROUND-WATER SAMPLES  
ROUND 1

Sample ID	Aluminum	Barium	Cadmium	Calcium	Chromium	Copper	Iron	Lead	Mercury	Nickel	Potassium	Silver	Sodium	Zinc	Cyanide
PM1 GM1	7,750(b)	74.0	5.0 U	27,800(d)	16.2	5.5	14,100(b,d)	5.4	0.2 U	11.0 U	3,700	1.0 U	24,500	30.6(c,d)	2.5 U(e)
PM1 GM1 F	34.9(a,b)	58.7	5.0 U	23,500(d)	5.0 U	6.0	65.8(a,b,d)	6.4	0.2 U	11.0 U	2,150	1.0 U	26,300	19.6(c,d)	NR
PM2 GM1	21,900(b)	105	6.2	7,930(d)	42.5	10.7	61,800(b,d)	13.2	0.2 U	13.1	5,050	1.0 U	7,830	41.0(c,d)	2.5 U(e)
PM2 GM1 F	35.3(a,b)	29.1	5.0 U	6,940(d)	5.0 U	5.2	38.2(a,b,d)	1.0 U	0.2 U	11.0 U	1,770	1.0 U	6,670	3.4(a,c,d)	NR
PM3 GM1	5,700(b)	53.7	5.0 U	4,290(d)	7.6	3.4	10,900(b,d)	4.5	0.2 U	11.0 U	2,900	1.0 U	10,100	15.7(a,c,d)	2.5 U(e)
PM3 GM1 F	26.3(a,b)	25.2	5.0 U	3,750(d)	5.0 U	1.0 U	16.9(a,b,d)	1.0 U	0.2 U	11.0 U	1,580	1.0 U	10,100	7.2(a,c,d)	NR
PM4 GM1	58,600	128	5.0 U	5,650	83.1	62.9(a)	137,000	40.7	0.2 U	19.3	6,980	1.1	11,100	70.1	10 U
PM4 GM1 F	391	2.0 U	5.0 U	1,830	5.0 U	5.1(a)	574	1.0 U	0.2 U	10.0 U	937 U	1.0 U	110,000	4.5	NR
PM5 GM1	45,900(b)	93.0	5.0 U	4,110(d)	72.0	19.5	96,100(b,d)	28.7	0.2 U	11.0 U	9,040	1.0 U	115,000	69.8(c,d)	2.5 U(e)
PM5 GM1 F	31.1(a,b)	2.2	5.0 U	943(d)	5.0 U	3.2	29.5(a,b,d)	1.0 U	0.2 U	11.0 U	937 U	1.0 U	112,000	3.1(a,c,d)	NR
PM6 GM1	16,100(b)	74.9	5.0 U	10,800(d)	22.8	8.8	35,400(b,d)	16.4	0.2 U	11.0 U	4,040	1.0 U	9,710	37.5(c,d)	2.5 U(e)
PM6 GM1 F	21.0 U(b)	16.0	5.0 U	9,140(d)	5.0 U	2.6	16.2(a,b,d)	1.0 U	0.2 U	11.0 U	1,710	1.0 U	10,700	3.6(a,c,d)	NR
PM7 GM1	36,700(b)	92.8	5.0 U	3,510(d)	48.3	66.3	56,900(b,d)	26.4	0.34	26.4	5,640	1.0 U	265,000	70.0(c,d)	78.4(f)
PM7 GM1 F	197(a,b)	6.6	5.0 U	2,180(d)	5.0 U	16.3	1,400(b,d)	1.0 U	0.2 U	11.0 U	937 U	1.0 U	266,000	4.6(a,c,d)	NR
PM8 GM1	12,900(b)	106	7.7	19,600(d)	15.5	8.3	27,600(b,d)	7.9	0.2 U	13.3	5,500	1.0 U	63,400	28.3(c,d)	2.5 U(e)
PM8 GM1 F	34.4(a,b)	57.6	5.0 U	20,200(d)	5.0 U	3.1	216(b,d)	1.0 U	0.2 U	11.8	3,880	1.0 U	72,100	10.9(a,c,d)	NR
PM9 GM1	11,300(b)	222	5.0 U	5,360(d)	12.5	10.6	23,300(b,d)	8.1	0.2 U	11.0 U	4,290	1.0 U	6,720	33.0(c,d)	2.5 U(e)
PM9 GM1 F	138(a,b)	161	5.0 U	5,050(d)	5.0 U	2.9	90.9(a,b,d)	1.0 U	0.2 U	11.0 U	2,610	1.0 U	6,160	15.2(a,c,d)	NR
PM9 GM1A(dup)	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	2.5 U(e)
PM10 GM1	49,600(b)	124.0	5.0 U	138,000(d)	40.5	17,400	62,300(b,d)	33.4	0.2 U	530	15,400	1.0 U	255,000	4,060(c,d)	19.9(f)

U - Not detected above limit indicated.

NR - Not Required

PM1 GM1 = total metals; PM1 GM1 F = filtered or dissolved metals

(a) - Value is less than five times the concentration of the contaminant in the associated blank and therefore may not be real.

(b) - Estimate value due to poor precision associated with matrix spike assessment.

(c) - Estimate value due to large variances between duplicate samples.

(d) - Estimate value due to potential chemical or physical interferences associated with ICP analysis.

(e) - Reject value due to extended holding time.

(f) - Estimate value due to extended holding time.

01/25/91

AR301712

ARROWHEAD PLATING SITE  
INORGANIC DATA FOR GROUND-WATER SAMPLES  
ROUND 1 (CONTINUED)

Sample ID	Aluminum	Barium	Cadmium	Calcium	Chromium	Copper	Iron	Lead	Mercury	Nickel	Potassium	Silver	Sodium	Zinc	Cyanide
	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
MJ10 GU1 F	7,700(b)	25.2	5.0 U	160,000(d)	5.0 U	2,550	53.8(a,b,d)	1.0 U	0.2 U	597	11,500	1.0 U	277,000	4,550(c,d)	NR
MJ11 GU1	2,950	40.5	5.0 U	34,000	5.5	2.4(a)	8,470	2.6	0.2 U	31.2	4,750(a)	1.0 U	116,000	167	10.0 U
MJ11 GU1 F	24.3	29.7	5.0 U	34,100	5.0 U	2.9(a)	501	1.0 U	0.2 U	24.7	3,950(a)	1.0 U	119,000	158	NR
MJ12 GU1	6,730(b)	44.8	5.0 U	6,610(d)	10.9	3.4	12,700(b,d)	12.8	0.2 U	11.0 U	1,930	1.0 U	139,000	18.3(c,d)	2.5 U(e)
MJ12 GU1 F	22.6(a,b)	15.0	5.0 U	7,590(d)	5.0 U	2.0	352(b,d)	1.0 U	0.2 U	11.0 U	1,010	1.0 U	156,000	11.9(a,c,d)	NR
MJ13 GU1	2,960(b)	28.0	5.0 U	26,900(d)	5.0 U	3.4	8,320(b,d)	2.6	0.2 U	12.1	3,580	1.0 U	229,000	47.5(c,d)	2.5 U(e)
MJ13 GU1 F	384(b)	19.3	5.0 U	25,400(d)	5.0 U	2.1	1,800(b,d)	1.0 U	0.2 U	11.0 U	1,700	1.0 U	243,000	44.6(c,d)	NR
AR1 GU1	54,900(c)	151	3.0 U	5,610	78.8	19.8	98,500	39.9	0.2 U	7.5	12,400	1.0 U	39,100	117	10.0 U
AR1 GU1 F	11.0 U(c)	9.7	3.0 U	2,270	3.0 U	5.5	17.8	1.0 U	0.2 U	5.0 U	771	1.0 U	40,600	9.5	NR
AR2 GU1	25,600(c)	86.6	3.0 U	4,690	53.2	16.8	88,900	21.1	0.2 U	5.0 U	12,600	1.0 U	125,000	54.7	11.6
AR2 GU1 F	35.4(a,c,f)	16.5	3.0 U	3,110(f)	3.0 U	8.0(f)	198(f)	1.0 U	0.2 U	5.0 U	7,600	1.0 U	137,000	6.8	NR
AR2 GU1A	28,000(c)	88.6	5.6(a)	4,530	58.3	15.2	90,600	22.4	0.2 U	5.0 U	13,800	1.0 U	120,000	55.3	10.0 U
AR2 GU1AF	470(c,f)	18.9	3.0 U	3,860(f)	3.0 U	16.2(f)	1,220(f)	1.0 U	0.2 U	5.0 U	8,320	1.0 U	139,000	5.8	NR
AR3 GU1	19,700(c)	66.1	3.0 U	6,050	22.1	4.8	36,300	14.8	0.2 U	5.0 U	2,480	1.0 U	118,000	29.9	15.1
AR3 GU1 F	33.6(a,c)	6.8	3.0 U	2,420	5.9	2.9	51.6	1.0 U	0.2 U	5.0 U	535	5.0 U	120,000	3.7	NR

U - Not detected above limit indicated.

NR - Not Required

MJ1 GU1 = Total metals; MJ1 GU1 F = Filtered or dissolved metals.

(a) - Value is less than five times the concentration of the contaminant in the associated blank and therefore is considered non-detectable.

(b) - Estimate value due to poor precision associated with matrix spike assessment.

(c) - Estimate value due to large variances between duplicate samples.

(d) - Estimate value due to potential chemical or physical interferences associated with ICP analysis.

(e) - Reject value due to extended holding time.

(f) - Estimate value due to extended holding time.

01/25/91

AR301713

ARROWHEAD PLATING SITE  
INORGANIC DATA FOR GROUND WATER SAMPLES  
ROUND II

Sample ID	Aluminum	Barium	Cadmium	Calcium	Chromium	Copper	Iron	Lead	Mercury	Nickel	Potassium	Silver	Sodium	Zinc	Cyanide
	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
M41-GH2	3,550	79.1	4.0 U	18,900	11.1	3.4	6,070	3.9	0.20 U	15.2(a)	2,270(a)	1.0 U(d)	24,400	44.3	5.0 U
M41-GH2 F	30.6	71.1	4.0 U	19,100	4.0 U	3.6	16.2	3.0 U	0.20 U	19.3(a)	1,120(a)	1.0 U(d)	24,600	35.3	NR
M42-GH2	5,060	52.0	4.0 U	9,000	4.9	3.0	13,400	3.0 U	0.20 U	10.0 U(a)	1,180(a)	1.0 U(d)	6,600	42.9	5.0 U
M42-GH2 F	11.0 U	35.2	4.0 U	9,620	4.0 U	4.0	7.6	3.0 U	0.20 U	10.0 U(a)	1,840(a)	1.0 U(d)	7,280	10.2	NR
M43 GH2	1,520	26.1	5.0 U	4,120	5.0 U	4.7(a)	2,570	1.9	0.20 U	10.0 U	871 U(b)	1.0 U	3,690	6.3	10.0 U
M43 GH2 F	26.2	14.5	5.0 U	4,470	5.0 U	6.0(a)	17.1(a)	4.6	0.20 U	10.0 U	979(a)	1.0 U	4,350	4.5	NR
M44 GH2	36,200(c)	83.8	3.0 U	2,900	50.3 U	38.9	76,500	28.0	0.20 U	5.0 U	4,770	1.0 U	110,000	56.6	10.0 U
M44 GH2 F	204(c)	1.0 U	3.0 U	758	3.0 U	6.2	224	2.0	0.20 U	5.0 U	1,170	1.0 U	108,000	5.3	NR
M45-GH2	18,100	40.9	5.0 U	1,110	28.2	10.4	34,500	11.6	0.20 U	10.0 U	3,480	1.0 U	119,000	36.2(a)	10.0 U(b)
M45-GH2 F	89.8	2.9	5.0 U	374	5.0 U	5.8	154	3.0 U	0.20 U	10.0 U	871 U	1.0 U	116,000	10.2(a)	NR
M46-GH2	22,000	104	5.0 U	10,500	30.7	10.5	46,700	19.5	0.20 U	10.0 U	3,660	1.0 U	10,500	46.3(a)	10.0 U(b)
M46-GH2 F	48.6	20.5	5.0 U	8,630	5.0 U	4.0	25.0	3.0 U	0.20 U	10.0 U	896	1.0 U	10,400	10.1(a)	NR
M47-GH2	26,200	70.2	5.0 U	2,820	31.1	53.3	31,200	23.1	0.20 U	14.6	3,070	1.0 U	229,000	63.0(a)	77.0(c)
M47-GH2 F	332	3.7	5.0 U	1,830	5.0 U	15.6	161	11.0	0.20 U	10.0 U	871 U	1.0 U	229,000	10.1(a)	NR
M48-GH2	8,930	110	7.4	11,000	16.3	2.8	17,500	10.5	0.20 U	10.1	3,650	1.0 U	60,000	45.3(a)	16.0(c)
M48-GH2 F	113	39.6	6.4	10,400	5.0 U	5.2	51.0	3.0 U	0.20 U	10.0 U	1,970	1.0 U	62,300	24.9(a)	NR
M49-GH2	3,910	241	5.0 U	4,960	5.2	10.0 U	6,980	3.0 U	0.20 U	10.0 U	2,290	1.0 U	4,280	28.6(a)	10.0 U(b)
M49-GH2 F	625	251	5.0 U	5,570	5.0 U	4.7	89.0	3.0 U	0.20 U	10.0 U	2,320	1.0 U	5,130	35.0(a)	NR
M410-GH2	32,500	70.2	7.5	153,000	22.4	730.0	29,400	11.6	0.20 U	550	11,500	1.0 U	246,000	4,080(a)	10.0 U(b)
M410-GH2 F	9,810	22.3	7.2	153,000	5.0 U	653.0	276	3.0 U	0.20 U	567	8,920	1.0 U	247,000	4,100(a)	NR

LEGEND:

- U - Not detected above limit indicated.
- NR - Not Requested
- (a) - Estimate values due to precision problems associated with the laboratory duplicate.
- (b) - Reject value due to extended holding times.
- (c) - Estimate value due to extended holding times.

AR301714

01/25/91

ARROWHEAD PLATING SITE  
INORGANIC DATA FOR GROUND-WATER SAMPLES  
ROUND II (continued)

Sample ID	Aluminum ug/L	Barium ug/L	Cadmium ug/L	Calcium ug/L	Chromium ug/L	Copper ug/L	Iron ug/L	Lead ug/L	Mercury ug/L	Nickel ug/L	Potassium ug/L	Silver ug/L	Sodium ug/L	Zinc ug/L	Cyanide ug/L
M411-G42	1,350	35.3	3.0 U	38,500	4.1	3.4	5,920	2.6	0.20 U	18.4	4,220	1.0 U	100,000	171	10 U
M411-G42 F	82.7	33.4	4.8	40,200	3.0 U	3.0	1,670	1.0 U	0.20 U	11.9	3,630	1.0 U	107,000	175	NR
M412-G42	1,040	17.6	5.0 U	6,190	5.0 U	1.8	2,160	3.0 U	0.20 U	10.0 U	871 U	1.0 U	150,000	17.4(a)	10.0 U(b)
M412-G42 F	18.7	12.5	5.0 U	5,760	5.0 U	2.4	338	3.0 U	0.20 U	10.0 U	871 U	1.0 U	157,000	10.6(a)	NR
M413-G42	2,470	23.4	5.0 U	26,300	5.0	326.0	5,560	3.0 U	0.20 U	10.0 U	2,720	1.3	227,000	69.4(a)	10.0 U(b)
M413-G42 F	494	11.8	5.0 U	16,700	5.0 U	3.1	778	3.0 U	0.20 U	10.0 U	1,460	1.0 U	235,000	41.5(a)	NR

LEGEND:

- U - Not detected above limit indicated.
- NR - Not Requested
- (a) - Estimate values due to precision problems associated with the laboratory duplicate.
- (b) - Reject value due to extended holding times.

01/25/91

AR301715

ARROWHEAD TESTING SITE  
SUMMARY OF METALS IN GROUND WATER  
ROUND III  
[ug/L]

Sample ID	Aluminum	Barium	Cadmium	Calcium	Chromium	Copper	Iron	Lead	Mercury	Nickel	Potassium	Silver	Sodium	Zinc	Cyanide
MW1 GW3	3,100	79.4	5.0 U	14,700	9.0 U	8.2(a,b)	2,030(d)	2.0 U(b)	0.35(a,b)	27.0 U	4,010 (a)	1.0 U(b)	24,200	97.7	5.0 U
MW1 GW3 F	1,250	64.5	5.0 U	11,300	9.0 U	8.2(a,b)	27 U(d)	2.0 U(b)	0.20(a,b)	27.0 U	4,640 (a)	1.0 U(b)	23,300	78.3	NR
MW2 GW3	6,530	75.8	5.0 U	6,280	13.8	9.9(a,b)	14,700(d)	5.3 (b)	0.22(a,b)	27.0 U	5,700 (a)	1.0 U(b)	4,430	35.4	5.0 U
MW2 GW3 F	118 U	44.0 U	5.0 U	2,580	9.0 U	5.6(a,b)	27 U(d)	2.0 U(b)	0.20(a,b)	27.0 U	5,210 (a)	1.0 U(b)	4,200	16.1	NR
MW3 GW3	6,890	52.1	5.0 U	2,380	13.5	3.3(a,b)	16,100(d)	2.0 U(b)	0.20(a,b)	27.0 U	4,720 (a)	1.0 U(b)	5,220	27.5	5.0 U
MW3 GW3 F	118 U	44.0 U	5.0 U	2,430	9.0 U	4.8(a,b)	27 U(d)	2.0 U(b)	0.20(a,b)	27.0 U	3,870 (a)	-- (b)	5,540	19.9	NR
MW4 GW3	46,800	80.4	5.0 U	2,010	58.2	54.0(b)	108,000(d)	2.0 U(b)	0.20(a,b)	27.0 U	8,050 (a)	1.0 U(b)	50,400	68.8	5.0 U
MW4 GW3 F	596	44.0 U	5.0 U	336(a)	9.0 U	8.5(a,b)	923(d)	2.0 U(b)	0.22(a,b)	27.0 U	4,830 (a)	2.6 (b)	79,700	13.1	NR
MW5 GW3	2,040	44.0 U	5.0 U	374(a)	9.0 U	4.0(a,b)	4,520(d)	2.0 U(b)	0.20(a,b)	27.0 U	4,840 (a)	1.0 U(b)	84,500	14.7	5.0 U
MW5 GW3 F	118 U	44.0 U	5.0 U	271(a)	9.0 U	9.0(a,b,e)	27 U(d)	2.0 U(b)	0.20(a,b)	27.0 U	4,310 (a)	1.0 U(b)	81,800	8.0 U	NR
MW6 GW3	1,320	44.0 U	5.0 U	2,900	9.0 U	2.5(a,b)	4,480(d)	-- (b)	0.22(a,b)	27.0 U	5,390 (a)	1.0 U(b)	10,700	10.8	5.0 U
MW6 GW3 F	118 U	44.0 U	5.0 U	2,940	9.0 U	3.4(a,b)	27 U(d)	2.0 U(b)	0.20(a,b)	27.0 U	4,980 (a)	1.0 U(b)	10,700	10.8	NR
MW7 GW3	4,030 (d,f)	9.0 U	5.0 U	812 U	9.0 U	21.1(b)	5,090(d)	2.4 (b)	0.30	16.0 U	1,090	13.1 (b)	182,000	8.0 U(d)	18.1
MW7 GW3 F	153 (d,f)	9.0 U	5.0 U	812 U	9.0 U	9.3(a,b)	160(d)	2.0 U(b)	0.22	16.0 U	700	1.0 U(b)	190,000	10.3(a,d)	NR
MW8 GW3	1,290 (d,f)	44.2(a)	5.0 U	6,600	9.0 U	6.0(a,b)	3,660(d)	2.0 U(b)	1.40	16.0 U	3,220	1.0 U(b)	42,200	19.4(a,d)	5.0 U
MW8 GW3 F	411 (d,f)	39.7(a)	5.3	6,230	9.0 U	3.6(a,b)	43.8(d)	2.0 U(b)	0.95	16.0 U	3,460	1.0 U(b)	40,600	24.5(a,d)	NR
MW9 GW3	4,290 (d,f)	167.0	5.0 U	2,540	9.9	3.8(a,b)	10,600(d)	2.0 U(b)	0.20	21.4 (a)	1,830	1.0 U(b)	2,960	9.0(a,d)	5.0 U
MW9 GW3 F	536 (d,f)	132.0	5.0 U	2,500	9.0 U	3.6(a,b)	55.8(d)	2.0 U(b)	0.30	16.0 U	1,340	1.0 U(b)	2,900	19.0(a,d)	NR
MW10 GW3	50,600(d,f)	21.4(a)	6.7	155,000	9.0 U	3.200(b)	21,600(d)	2.0 U(b)	0.20	667.0	15,200	1.0 U(b)	267,000	5,600 (d)	128.0
MW10 GW3 F	41,400(d,f)	12.4(a)	9.2	199,000	9.0 U	3.100(b)	1,890(d)	2.0 U(b)	0.20	696.0	14,800	1.0 U(b)	252,000	5,220 (d)	NR
MW11 GW3	837	44.0 U	5.0 U	31,900	9.0 U	1.6(a,b)	6,010(d)	2.0 U(b)	0.20(b)	27.0 U	8,200 (a)	1.0 U(b)	68,200	200.0	5.0
MW11 GW3 F	118 U	44.0 U	5.0 U	31,300	9.0 U	5.1(a,b)	494(d)	2.0 U(b)	0.20(b)	27.0 U	7,710	1.0 U(b)	73,300	192.0	NR
MW12 GW3	900	44.0 U	5.0 U	11,500	9.0 U	3.2(a,b)	5,210(d)	2.0 U(b)	0.20(b)	27.0 U	5,010 (a)	1.0 U(b)	177,000	13.5	5.0
MW12 GW3 F	283 (a)	44.0 U	5.0 U	11,100	9.0 U	2.8(a,b)	3,880(d)	2.0 U(b)	0.20(b)	27.0 U	5,180 (a)	1.0 U(b)	167,000	13.9	NR
MW13 GW3	2,010	44.0 U	5.0 U	7,010	9.0 U	3.9(a,b)	3,810(d)	2.0 U(b)	0.20(b)	27.0 U	5,800 (a)	1.0 U(b)	203,000	24.0	5.0
MW13 GW3 F	801	44.0 U	5.0 U	9,060	9.0 U	5.9(a,b)	154(d)	2.0 U(b)	0.20(b)	27.0 U	5,730 (a)	1.0 U(b)	206,000	28.2	NR

AR301716

ARROWHEAD MINING SITE  
SUMMARY OF METALS IN GROUND WATER  
ROUND III (CONTINUED)  
[ug/L]

Sample ID	Aluminum	Barium	Cadmium	Calcium	Chromium	Copper	Iron	Lead	Mercury	Nickel	Potassium	Silver	Sodium	Zinc	Cyanide
MW21 GW3	142,000	66.3	10.8	144,000	24.8 (a,d)	11,000	97,700 (d)	5.4 (b)	0.20 U(b,d)	553.0	19,800	1.2 (b)	147,900 (d)	3,660.0	5.0 U
MW21 GW3 F	99,600(d)	44.0 U	11.9	156,000	9.0 U(a)	12,200	41,600	2.0 U(b)	0.20 U	621.0	17,900	1.0 U(b)	148,000	4,170.0	NR
MW22 GW3	11,800	95.7	5.0 U	2,440	20.8 (a,d)	8,690	38,500 (d)	11.2 (b)	0.20 U(b,d)	27.0 U	3,060 (a)	1.0 U(b)	11,660 (d)	85.5	5.0 U
MW22 GW3 F	150(a,d)	44.0 U	5.0 U	1,920	9.0 U(a)	7.8(a)	80.8	2.0 U(b)	0.20 U	27.0 U	1,670 (a)	1.0 U(b)	11,250	21.5	NR
MW23 GW3	21,500	117.0	5.0 U	44,500	45.9 (a,d)	21.2	56,300 (d)	21.7 (b)	0.20 U(b,d)	48.3	12,600	1.0 U(b)	318,000 (d)	174.0	18.3
MW23 GW3 F	347(a,d)	51.0	5.0 U	38,300	9.0 U(a)	4.7(a)	3,880	2.0 U(b)	0.20 U	29.0	8,660	1.0 U(b)	320,000	76.6	NR
MW24 GW3	4,000	44.0 U	5.0 U	52,100	16.5 (a,d)	7.2	10,300 (d)	2.0 U(b)	0.58 (b,d)	32.6	5,660	1.0 U(b)	294,000 (d)	52.8	22.9
MW24 GW3 F	1,200(d)	44.0 U	5.0 U	51,300	9.0 U(a)	5.6(a)	1,680	2.0 U(b)	0.20 U	27.2	4,860	1.0 U(b)	292,000	48.4	NR
MW25 GW3	2,540	78.1	5.0 U	1,910	11.8 (a,d)	6.8(a)	7,320 (d)	2.6 (b)	0.20 U(b,d)	27.0 U	1,440 (a)	1.0 U(b,d)	16,440	14.5	5.0 U
MW25 GW3 F	307(a,d)	44.0 U	5.0 U	1,810	9.0 U(a)	6.0(a)	232	2.0 U(b)	0.20 U	27.0 U	1,490 (a)	1.0 U(b)	17,520	11.1	NR
MW26 GW3	23,700	94.6	5.0 U	5,430	46.4 (d)	12.8	61,800 (d)	6.6 (b)	0.20 U(b,d)	27.0 U	7,260	1.0 U(b)	54,600 (d)	59.6	5.0 U
MW26 GW3 F	122,000(d)	44.0 U	5.0 U	3,250	9.0 U(a)	5.0(a)	310	2.0 U(b)	0.20 U	27.0 U	2,240 (a)	1.0 U(b)	52,400	11.5	NR
AR1 GW3	4,310(d,f)	19.6(a)	5.0 U	897	16.0	10.3(b)	11,100 (d)	3.5 (b)	0.20 U	41.6	1,880	1.0 U(b)	199,000	39.9(a,d)	5.0 U
AR1 GW3 F	118 U(d,f)	9.0 U	5.0 U	812 U	9.0 U	4.2(a,b)	49.3 (d)	2.0 U(b)	0.20 U	16.0 U	835	1.0 U(b)	34,200	13.0(a,d)	NR
AR2 GW3	9,920(d,f)	52.9(a)	5.0 U	13,200	25.2	9.5(a,b,e)	30,400 (d)	3.2 (b)	0.30	16.0 U	6,980	1.0 U(b)	103,000	23.5(a,d)	11.9
AR2 GW3 F	124(d,f)	21.7(a)	5.0 U	11,300	9.0 U	11.8(b)	38.2 (d)	2.0 U(b)	0.20 U	16.0 U	5,850	1.0 U(b)	123,000	11.9(a,d)	NR
AR3 GW3	21,800(d,f)	71.0	5.0 U	8,160	15.3	8.4(a,b)	56,400 (d)	6.9 (b)	0.20 U	16.0 U	1,960	1.0 U(b)	111,000	35.2(a,d)	34.1
AR3 GW3 F	118 U(d,f)	9.0 U	5.0 U	812 U	9.0 U	13.4(b)	68.0 (d)	2.0 U(b)	0.20 U	16.0 U	310	1.0 U(b)	106,000	78.9(d)	NR
AR3 GW3A	8,620(d,f)	34.7(a)	5.0 U	5,800	17.3	10.4(b)	23,500 (d)	5.2 (b)	0.22	19.2 (a)	815	1.0 U(b)	108,000	8.0 U(d)	29.6
AR3 GW3A F	796(d,f)	943.0	5.0 U	5,160	9.0 U	27.5(b)	1,108 (d)	4.9 (b)	0.20 U	16.0 U	1,420	1.0 U(b)	121,000	552.0(d)	NR

J - Not detected above the value indicated.

R - Not requested.

Less than five times the concentration in the associated blank and should be considered a non-detect.

Value due to bias associated in the matrix spike assessment.

Value due to poor recovery associated with matrix spike.

Value due to poor laboratory precision.

Value due to low correlation for the method of standard additions.

Value due to potential chemical or spectral interference.

AR301717

# ICF KAISER ENGINEERS

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TO: Claudia Brand

FROM: Jay Kuhn

DATE: July 16, 1990

SUBJECT: Arrowhead Plating Site, Data Validation, 3 Soil Samples and 2 Water Samples, Semivolatile and Volatile Organic Analysis, Versar Inc., Virginia.

REFERENCE: Validation 5, Versar Control Number 2549 and 2502, Surface Soil, Groundwater

A level I validation was performed on the organic analytical data from 3 soil samples and 1 water sample collected at the Arrowhead Plating Site as part of the Remedial Investigation/Feasibility Study. The samples were analyzed for EPA Target Compound List (TCL) semivolatile and volatile organics by Versar Inc., Springfield, Virginia. A volatile organic compounds trip blank was also included in the sample package. Validation was performed in accordance with the EPA Functional Guidelines for Evaluating Organics Analyses (February 1, 1988). A copy of the checklist has been provided as attachment for your information.

The samples included in the data package are the following.

<u>Water</u>	<u>Soil</u>
MW1-GW1	SS29
Trip Blank 10	SS30
	SS31

**Overall Data Assessment:** The overall laboratory performance met quality control criteria with the following exceptions:

1. Data for the non-detected compounds carbon disulfide, vinyl acetate, 4-methyl-2-pentanone, and 2-hexanone in sample MW-1 GW-1 should be rejected due to the non-compliance of the continuing calibration standard. In addition, the detected value for acetone should be considered estimated.
2. Sample MW-1 GW-1 the identification of 2-butanone does not meet criteria for SW846 Method 8240 or EPA Contract Laboratory Program. The result is qualified as tentatively identified.

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3. The method detection limits for semivolatile analysis of SS29, SS30, and SS31 are elevated by a factor of 1.1.

The following criteria were reviewed in validating the data:

1. Holding Time: All criteria met.
2. GC/MS Tune: All criteria met.
3. Calibration:

Volatile TCL:

Instruments Y and U were used to perform the volatile analysis. Calibration results for each instrument are as follows:

Instrument Y

Initial: 4/25/90, meets criteria.

Continuing: 4/30/90, 7 compounds have a percent Deviation (%D) > 25%.

Impact on data: Results for compounds in MW1-GW1 which are quantitated on continuing calibrations with percent deviation (%D) > 25% should be qualified as follows: detected compound values should be estimated for acetone and all non-detected data should be rejected for carbon disulfide, vinyl acetate, 4-methyl-2-pentanone, and 2-hexanone.

Instrument U

Initial: 4/23/90, meets criteria.

Continuing: 4/27/90, 4 compounds have a %D > 25%.

Impact on data: The percent deviation was greater than 25% for bromomethane, chloroethane, acetone, and carbon disulfide. The samples potentially impacted were SS29, SS30, and SS31. Since the noted analytes were not quantitated in these samples, no action is warranted.

Semivolatile TCL:

Instrument Z was used to perform semivolatile analysis. Calibration results for the instrument are as follows:

Instrument Z

Initial: 5/15/90, 1 compound has a percent relative standard deviation (%RSD) > 30%.

Impact on data: The percent deviation was greater than 30% for 3-nitroaniline. The samples potentially impacted were SS29, SS30, and SS31. Since the noted analyte was not quantitated in these samples, no action is warranted.

Continuing: 5/16/90, 1 compound has a %D > 25%.

Impact on data: The percent deviation was greater than 25% for 3-nitroaniline. Although sample results were not impacted, the matrix spike and matrix spike duplicate for SS29 could potentially be impacted. However, this is not within the scope of a Level I validation, and no action is warranted.

4. Blanks:

Blank analysis results were assessed to evaluate the potential of contamination contribution by the sampling and/or analytical process. Field blanks, trip blanks, and laboratory blanks were included in this data package. The maximum concentration of contamination found in any of the field, trip, or laboratory blanks and the impact on data were as follows:

<u>Contamination</u>	<u>Detected Concentration of Contamination</u>	<u>Contamination Considered Non-detect up to Concentration</u>	<u>Blank I.D.</u>
Acetone	15 ug/L	150 ug/L	Trip Blank 10
Methylene Chloride	1 ug/L	10 ug/L	VBLK17

Impact on data: Acetone and methylene chloride were not detected in any of the associated samples; therefore, no action is warranted.

5. Surrogate Spike: All criteria were met for volatile and semivolatile analyses.

6. Matrix Spike/Matrix Spike Duplicate:

Volatile: Meets criteria.

Semivolatile: The matrix spike, SS29MS, had three matrix spikes out and the matrix spike duplicate, SS29MSD, had two matrix spikes out. In addition, the relative percent deviation (RPD) for acenaphthene was out at 21%. SS29 is not impacted by these variances nor are the individual samples associated with this case.

7. Field Duplicates: No field duplicates submitted for this analytical sequence.

8. Internal Standard (IS) Performance: All submitted samples meet IS criteria.

9. TCL Compound Identification:

Sample MW-1 GW-1 the identification of 2-Butanone does not meet criteria for SW846 Method 8240 or EPA Contract Laboratory Program. The mass ion 39 in the sample spectrum is not within 20% of the standard spectrum. The compound was not qualified as tentatively identified on the data summary sheet.

10. Compound Quantitation and Reported Detection Limits:

A dilution factor of 1.1 resulted for the semivolatile TCL analysis of SS29, SS30 and SS31. This occurred as a result of the final extract being spilt for pesticide analysis. It should be noted that the field chain of custody did not designate these samples for pesticide analysis. As a result of this dilution, the minimum method detection limits were elevated by a factor of 1.1.

11. Tentatively Identified Compounds: All criteria met

12. System Performance: System performance acceptable.

# ICF KAISER ENGINEERS

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TO: Claudia Brand

FROM: Jay Kuhn

DATE: July 17, 1990

SUBJECT: Arrowhead Plating Site, Data Validation, 14 Water Samples Volatile Organic Analysis, Versar Inc., Virginia.

REFERENCE: Validation 6, Versar Control Number 2516, Groundwater

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A level I validation was performed on the organic analytical data from 14 water samples collected at the Arrowhead Plating Site as part of the Remedial Investigation/Feasibility Study. The samples were analyzed for EPA Target Compound List (TCL) volatile organics by Versar Inc., Springfield, Virginia. Validation was performed in accordance with the EPA Functional Guidelines for Evaluating Organics Analyses (February 1, 1988). A copy of the checklist has been provided as an attachment for your information.

The samples included in the data package are the following.

MW-2 GW-1	MW-9 GW-1A
MW-3 GW-1	MW-10 GW-1
MW-5 GW-1	MW-12 GW-1
MW-6 GW-1	MW-13 GW-1
MW-7 GW-1	Trip Blank 11
MW-8 GW-1	Trip Blank 12
MW-9 GW-1	Equip Blank 2

## Overall Assessment of Data for Samples Evaluated:

In order to quantify target compounds, dilutions were done. As a result, the following samples had method detection limits increased by the following dilution factors:

<u>Sample ID:</u>	<u>Dilution Factor:</u>
MW8-GW1	100
MW9-GW1	2000
MW10-GW1	100
MW12-GW1	100
MW13-GW1	100

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Given the extensive problems with this data set, a summary of the available data is given.

Sample MW-2 GW-1: The original analysis of this sample (MW-2 GW-1) is not usable for the following reasons: the analysis was over-diluted by a factor of 100, extensive contamination was present from the previous analysis, and a surrogate was noncompliant (1,2-dichloroethane-D4). The reextraction (MW-2 GW-1RE) is usable. As a result a not meeting holding time, the detected result for trichloroethene and quantitation limits for the remaining non-detected compounds should be considered estimated.

Sample MW-3 GW-1: The original analysis of this sample (MW-3 GW-1) is not usable for the following reasons: the analysis was over-diluted by a factor of 100 and a surrogate was noncompliant (1,2-dichloroethane-D4). The reextraction (MW-3 GW-1RE) is usable. No target compounds were detected; therefore, as a result a not meeting holding time, quantitation limits for non-detected compounds should be considered estimated.

Sample MW-5 GW-1: The original analysis of this sample (MW-5 GW-1) is not usable for the following reasons: the analysis was over-diluted by a factor of 100, extensive contamination was present from the previous analysis, and a surrogate was noncompliant (1,2-dichloroethane-D4). The reextraction (MW-5 GW-1RE) is usable. No target compounds were detected; therefore, as a result a not meeting holding time, quantitation limits for non-detected compounds should be considered estimated.

Sample MW-6 GW-1: The original analysis of this sample (MW-6 GW-1) is not usable for the following reasons: the analysis was over-diluted by a factor of 100 and a surrogate was noncompliant (1,2-dichloroethane-D4). The reextraction (MW-6 GW-1RE) is usable. As a result a not meeting holding time, the result for tetrachloroethene and quantitation limits for the remaining non-detected compounds should be considered estimated.

Sample MW-7 GW-1: The original analysis of this sample (MW-7 GW-1) is usable. The potential impact on the data is as follows: detected compound values for acetone, carbon disulfide, vinyl acetate, 4-methyl-2-pentanone, and 2-hexanone should be estimated and reject the data of these compounds when they are non-detected. These compounds were not detected; therefore, the quantitation limits for these compounds should be rejected.

Sample MW-8 GW-1: The original analysis of this sample (MW-8 GW-1) is usable. The potential impact on the data is as follows: detected compound values for acetone, carbon disulfide, vinyl acetate, 4-methyl-2-pentanone, and 2-hexanone should be estimated and reject the data of these compounds when they are non-detected. Acetone was detected and therefore should be considered estimated; the quantitation limits for carbon disulfide, vinyl acetate, 4-methyl-2-pentanone, and 2-hexanone should be rejected.

Sample MW-9 GW-1: The original analysis of this sample (MW-9 GW-1) is not usable for the following reasons: the reported results for this analysis (MW-9 GW-1) were qualitatively verified from the diluted reanalysis (MW-9 GW-1DL). The results reported from the diluted reanalysis are usable, but these results should be qualified for methylene chloride detected in the associated reagent blank. In addition, for not meeting holding time positive results and quantitation limits for nonpositive results should be considered estimated. The impact on the data is as follows: the detected results for 1,1-dichloroethene, 1,1,1-trichloroethane, and tetrachloroethene as well as the quantitation limits for the remaining non-detected compounds should be considered estimated.

Sample MW-9 GW-1A: The original analysis of this sample (MW-9 GW-1A) is not usable for the following reasons: the reported results for this analysis (MW-9 GW-1A) were qualitatively verified from the diluted reanalysis (MW-9 GW-1ADL). The results reported from the diluted reanalysis are usable, but these results should be qualified for methylene chloride detected in the associated reagent blank. In addition, for not meeting holding time positive results and quantitation limits for nonpositive results should be considered estimated. The impact on the data is as follows: the detected results for 1,1-dichloroethene, 1,1,1-trichloroethane, and tetrachloroethene as well as the quantitation limits for the remaining non-detected compounds should be considered estimated.

Sample MW-10 GW-1: The original analysis of this sample (MW-10 GW-1) is not usable for the following reasons: the reported results for this analysis (MW-10 GW-1) were qualitatively verified from the reextraction (MW-10 GW-1RE). The results reported from the reextraction are usable, but these results should be qualified for methylene chloride detected in the associated reagent blank. In addition, for not meeting holding time positive results and quantitation limits for nonpositive results should be considered estimated. The impact on the data is as follows: the detected results for 1,1-dichloroethene, 1,1,1-trichloroethane, trichloroethene and tetrachloroethene as well as the quantitation limits for the remaining non-detected compounds should be considered estimated.

Sample MW-12 GW-1: The original analysis of this sample (MW-12 GW-1) is not usable for the following reasons: the reported results for this analysis (MW-12 GW-1) were qualitatively verified from the reextraction (MW-12 GW-1RE). The results reported from the reextraction are usable, but these results should be qualified for methylene chloride detected in the associated reagent blank. In addition, for not meeting holding time positive results and quantitation limits for nonpositive results should be considered estimated. The impact on the data is as follows: the detected results for 1,1-dichloroethene(~~total~~), 1,1,1-trichloroethane, trichloroethene, and tetrachloroethene as well as the quantitation limits for the remaining non-detected compounds should be considered estimated.

Sample MW-13 GW-1: The original analysis of this sample (MW-13 GW-1) is not usable for the following reasons: the reported results for this analysis (MW-13 GW-1) were qualitatively verified from the reextraction (MW-13 GW-1RE). The results reported from the reextraction are usable, but these results should be qualified for methylene chloride detected in the associated reagent blank. In addition, for not meeting holding time positive results and quantitation limits for nonpositive results should be considered estimated. The impact on the data is as follows: the detected results for ~~1,1,1-trichloroethane~~, 1,2-dichloroethene, 1,1,1-trichloroethane, trichloroethene and tetrachloroethene as well as the quantitation limits for the remaining non-detected compounds should be considered estimated.

Sample Equip Blank 2: The original analysis of this sample (Equip Blank 2) is not usable for the following reasons: the reported results for this analysis (Equip Blank 2) were qualitatively verified from the reextraction (Equip Blank 2RE). The results reported from the reextraction are usable, but these results should be qualified for methylene chloride detected in the associated reagent blank. In addition, for not meeting holding time positive results and quantitation limits for nonpositive results should be considered estimated. The impact on the data is as follows: the detected methylene chloride is considered non-detect and the detected result for acetone as well as the quantitation limits for the remaining non-detect compounds should be considered estimated.

Sample Trip Blank 11: The original analysis of this sample (Trip Blank 11) is not usable for the following reasons: the reported results for this analysis (Trip Blank 11) were qualitatively verified from the reextraction (Trip Blank 11RE). The results reported from the reextraction are usable, but these results should be qualified for methylene chloride detected in the associated reagent blank. In addition, for not meeting holding time positive results and quantitation limits for nonpositive results should be considered estimated. The impact on the data is as follows: the detected methylene chloride is considered nondetect and the quantitation limits for the remaining nondetect compounds should be considered estimated.

Sample Trip Blank 12: The original analysis of this sample (Trip Blank 12) is not usable for the following reasons: the reported results for this analysis (Trip Blank 12) were qualitatively verified from the reextraction (Trip Blank 12RE). The results reported from the reextraction are usable, but these results should be qualified for methylene chloride detected in the associated reagent blank. In addition, for not meeting holding time positive results and quantitation limits for nonpositive results should be considered estimated. The impact on the data is as follows: the detected methylene chloride is considered nondetect and the detected result for acetone as well as the quantitation limits for the remaining nondetect compounds should be considered estimated.

The following criteria were reviewed in validating the data:

1. Holding Time:

The following samples failed to meet holding time criteria:

MW-2 GW-1	MW-10 GW-1
MW-3 GW-1	MW-12 GW-1
MW-5 GW-1	MW-13 GW-1
MW-6 GW-1	Trip Blank 11
MW-9 GW-1	Trip Blank 12
MW-9 GW-1A	Equip Blank 2

Impact on data: For all samples positive results and quantitation limits for nonpositive results should be considered estimated.

2. GC/MS Tune: All criteria met.

3. Calibration:

Instruments Y and W were used to perform the volatile analysis. Calibration results for each instrument are as follows.

Instrument Y

Initial: 4/25/90, meets criteria.

Continuing: 4/30/90, 7 compounds have a %D > 25%.

Impact on data: Results for compounds which are quantitated on continuing calibrations with percent deviation (%D) > 25% should be qualified as follows: detected compound values for acetone, carbon disulfide, vinyl acetate, 4-methyl-2-pentanone, and 2-hexanone should be estimated and reject the data of these compounds when they are non-detected. The samples potentially impacted are MW-8 GW-1 and MW-7 GW-1. The detection of acetone in MW-8 GW-1 should be considered estimated. The non-detect data for carbon disulfide, vinyl acetate, 4-methyl-2-pentanone, and 2-hexanone should be rejected for MW-8 GW-1 and MW-7 GW-1.

Instrument W

Initial: 4/27/90, meets criteria.

Continuing: 4/27/90, 1 compound has a %D > 25%.

Impact on data: Results for the compound acetone which is quantitated on a continuing calibration with a percent deviation (%D) > 25% should be qualified as follows: the detected compound value for acetone should be estimated. The samples potentially impacted are MW-13 GW-1, MW-12 GW-1, MW-10 GW-1, Trip Blank 12, Trip Blank 11, Equip Blank 2, MW-9 GW-1A, and MW-9 GW-1. Due to loss of data during transfer from disk to tape, these analyses are not usable.

Initial: 4/30/90, meets criteria.

Initial: 5/7/90, meets criteria.

Continuing: 5/8/90, 1 compound has a %D > 25%.

Impact on data: Results for the compound chloromethane which is quantitated on a continuing calibration with a percent deviation (%D) > 25% should be qualified as follows: the detected compound value for chloromethane should be estimated. The samples potentially impacted are Equip Blank 2RE (reextraction), Trip Blank 11RE (reextraction), Trip Blank 12RE (reextraction), MW-9 GW-1DL (dilution), MW-9 GW-1ADL (dilution), MW-10 GW-1RE (reextraction), MW-10 GW-1RE (reextraction), MW-12 GW-1RE (reextraction), and MW-13 GW-1RE (reextraction). This compound was not detected in these samples.

4. **Blanks:**

The intent of blank analysis results are to evaluate the potential of contamination contribution by the sampling and/or analytical process. Both field blanks and laboratory blanks are included in this data package. The maximum concentration of contamination found in any of the field or laboratory blanks are as follows:

<u>Contamination</u>	<u>Detected Concentration of Contamination</u>	<u>Contamination Considered Non-detect up to Concentration</u>	<u>Blank I.D.</u>
Methylene Chloride	1 ug/L	10 ug/L	VBLK17
Methylene Chloride	5 ug/L	50 ug/L	VBLK21
Acetone	8 ug/L	80 ug/L	VBLK45
Acetone	15 ug/L	150 ug/L	VBLK66
Acetone	12 ug/L	120 ug/L	Equip Blank 2
Methylene Chloride	4 ug/L	40 ug/L	Equip Blank 2RE
Acetone	10 ug/L	100 ug/L	Equip Blank 2RE
Acetone	13 ug/L	130 ug/L	Trip Blank 11
Methylene Chloride	5 ug/L	50 ug/L	Trip Blank 11RE
Acetone	13 ug/L	130 ug/L	Trip Blank 12
Methylene Chloride	6 ug/L	60 ug/L	Trip Blank 12RE
Acetone	10 ug/L	100 ug/L	Trip Blank 12RE

5. **Surrogate Spike:**

Surrogate recovery windows created from EPA Contract Laboratory Program data base. The following samples had the same surrogate out for the original analyses: MW-2 GW-1, MW-3 GW-1, MW-5 GW-1, and MW-6 GW-1.

Impact on data: The data for these analyses are not usable (see Overall Assessment Section).

6. **Matrix Spike/Matrix Spike Duplicate:**

All recoveries and Relative Percent Deviations (RPD's) meet criteria.

7. **Field Duplicates:**

The field duplicates are MW-9 GW-1 and MW-9 GW-1A as well as MW-9 GW-1DL (dilution) and MW-9 GW-1ADL (dilution). Samples MW-9 GW-1 and MW-9 GW-1A were analyzed within holding time but the results exceeded the linear range of the curve. The dilutions were within linear range but exceeded the holding time. These results and Relative Percent Deviations (RPDs) are as follows:

<u>Compound</u> <u>Quantitated</u>	<u>MW-9 GW-1</u>	<u>MW-9 GW-1A</u>	<u>RPDs</u>
1,1-Dichloroethene	11,000 ug/L	9,900 ug/L	11%
1,1,1-Trichloroethane	180,000 ug/l	160,000 ug/L	12%
Trichloroethene	610 ug/L	580 ug/L	5%
Tetrachloroethene	28,000 ug/L	25,000 ug/L	11%

The results for the reanalysis at a dilution (suffix DL) are as follows:

<u>Compound</u> <u>Quantitated</u>	<u>MW-9 GW-1DL</u>	<u>MW-9 GW-1ADL</u>	<u>RPDs</u>
1,1-Dichloroethene	9,900 ug/L	9,800 ug/L	1%
1,1,1-Trichloroethane	150,000 ug/L	140,000 ug/L	7%
Trichloroethene	ND	ND	0%
Tetrachloroethene	26,000 ug/L	26,000 ug/L	0%
Methylene Chloride	14,000 ug/L	15,000 ug/L	7%

Legend:ND-not detected as a result of the dilution.

Impact on data: The field duplicates reflect good precision. It is in the reviewers judgement that there is no significant impact on the data.

8. **Internal Standard (IS) Performance:**

All submitted samples meet IS criteria except MW-6 GW-1MS (matrix spike) and MW-6 GW-1MSD (matrix spike duplicate). Both samples had low internal standards (1,4-difluorobenzene and chlorobenzene). Impact on data: positive results which are quantitated from the internal standards should be estimated as well as quantitation limits for non-positive results.

9. **TCL Compound Identification:**

As a result of the failure of the data system of instrument W,

identification of compounds were from the reextraction (outside holding time) and the values reported were from the original extraction. This applies to the following samples: MW-9 GW-1, MW-9 GW-1A, MW-10 GW-1, MW-12 GW-1, MW-13 GW-1, Equip Blank 2, Trip Blank 11, and Trip Blank 12.

10. Compound Quantitation and Reported Detection Limits:

As a result of over-dilution, method quantitation limits were not met for the following files: MW-2 GW-1, MW-3 GW-1, MW-5 GW-1, and MW-6 GW-1. It should be noted that reextractions (outside holding time) are available for these samples. In addition, in order to quantify target compounds, dilutions were done. As a result, the following samples had method detection limits increased by the following dilution factors:

<u>Sample ID:</u>	<u>Dilution Factor:</u>
MW8-GW1	100
MW9-GW1	2000
MW10-GW1	100
MW12-GW1	100
MW13-GW1	100

11. Tentatively Identified Compounds: All criteria met.

12. System Performance:

For instrument W, during transfer of data from disk to tape, all data was lost. This impacts the results for the following samples: MW-2 GW-1, MW-3 GW-1, MW-5 GW-1, MW-6 GW-1, MW-9 GW-1, MW-9 GW-1A, MW-10 GW-1, MW-12 GW-1, MW-13 GW-1, Trip Blank 11, Trip Blank 12, and Equip Blank 2.

# **ICF KAISER ENGINEERS**

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703/934-3300

TO: Claudia Brand

FROM: Jay Kuhn

DATE: July 16, 1990

SUBJECT: Arrowhead Plating Site, Data Validation, 12 Water  
Samples, Semivolatile Organic Analysis, Versar Inc., Virginia.

REFERENCE: Validation 7, Versar Control Number 2516, Groundwater

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A level I validation was performed on organic analytical data from 14 water samples collected at the Arrowhead Plating Site as part of the Remedial Investigation/Feasibility Study. The samples were analyzed for EPA Target Compound List (TCL) semivolatile organics by Versar Inc., Springfield, Virginia. Validation was performed in accordance with the EPA Functional Guidelines for Evaluating Organics Analyses (February 1, 1988). A copy of the checklist has been provided as an attachment for your information.

The samples included in the data package are the following.

MW-2 GW-1	MW-9 GW-1A
MW-3 GW-1	MW-10 GW-1
MW-5 GW-1	MW-12 GW-1
MW-6 GW-1	MW-13 GW-1
MW-7 GW-1	Equip Blank 2
MW-8 GW-1	
MW-9 GW-1	

## **Overall Assessment of Data for Samples Evaluated:**

The non-detected data results for the semivolatile acid fraction of sample MW-10 GW-1 should be rejected due to poor surrogate recovery.

AR301731

The following criteria were reviewed in validating the data:

1. Holding Time: All criteria met.
2. GC/MS Tune: All criteria met.
3. Calibration:

Instrument T was used to perform the semivolatile analysis. Calibration results for the instrument are as follows.

#### Instrument T

Initial: 5/18/90, 1 compound, benzoic acid, has a %RSD > 30%.

Impact on data: Results for compounds which are quantitated on initial calibrations with percent deviation (%D) > 30% should be qualified as follows: detected compound values for benzoic acid should be estimated. The samples potentially impacted are MW-2 GW-1, MW-3 GW-1, MW-5 GW-1, MW-6 GW-1, and MW-7 GW-1. Benzoic acid was not detected in any of these samples.

Continuing: 5/21/90, meets criteria.

4. Blanks:

The intent of blank analysis results are to evaluate the potential of contamination contribution by the sampling and/or analytical process. Both field blanks and laboratory blanks are included in this data package. No compounds were detected in the blanks and therefore there is no impact on the data.

5. Surrogate Spike:

Sample MW-10 GW-1 had one acid surrogate at less than 10%. It should be noted that no more sample was available for reextraction.

Impact on data: The detection of compounds from the acid fraction should be considered estimated and reject the non-detect data for the acid fraction.

6. Matrix Spike/Matrix Spike Duplicate: not done with this analytical sequence.

7. Field Duplicates:

The field duplicates are MW-9 GW-1 and MW-9 GW-1A. No compounds were detected in either MW-9 GW-1 or MW-9 GW-1A.

8. Internal Standard (IS) Performance: meets criteria.

9. TCL Compound Identification: All qualitative analysis acceptable.
10. Compound Quantitation and Reported Detection Limits: All quantitation limits were met. Instrument detection limits were not supplied.
11. Tentatively Identified Compounds: All criteria met.
12. System Performance: Acceptable

# ICF KAISER ENGINEERS

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TO: Claudia Brand

FROM: Jay Kuhn

DATE: July 17, 1990

SUBJECT: Arrowhead Plating Site, Data Validation, 2 Soil Boring Samples,  
4 Water Samples, Semivolatile Organic Analysis, Versar  
Inc., Virginia.

REFERENCE: Validation 8, Versar Control Number 2753 and 2763, Soil Boring,  
Groundwater

A level I validation was performed on the organic analytical data from 2 soil boring samples, 2 groundwater samples, and field blanks collected at the Arrowhead Plating Site as part of the Remedial Investigation/Feasibility Study. The samples were analyzed for EPA Target Compound List (TCL) semivolatile organics by Versar Inc., Springfield, Virginia. Validation was performed in accordance with the EPA Functional Guidelines for Evaluating Organics Analyses (February 1, 1988). A copy of the checklist has been provided as an attachment for your information.

The samples included in the data package are the following.

Water Sample:

Equipment Blank 3  
Equipment Blank 4  
MW1-GW2  
MW2-GW2

Soil Sample:

SB4-SS3 (10-12')  
SB4-SS3A (10-12')

Note: Samples Trip Blank 13 and Trip Blank (received 5/18/90) were listed in the narrative, but no data for these samples were submitted in this data package.

**Overall Assessment of Data for Samples Evaluated:**

The reagent blank SBLK74 is noncompliant with respect to surrogate recoveries. The laboratory submitted another reagent blank, SBLK71, which was extracted on the same day as the soil samples SB4-SS3 and SB4-SS3A; however, this blank was not associated with the extraction sequence of these soil samples. Although the use of SBLK71 is questionable with respect to determining contamination contribution from the extraction process, it is in the reviewers judgement that the noncompliant surrogate recoveries is an isolated occurrence and does not reflect a fundamental problem with the extraction process; therefore, no qualification of the data is warranted.

AR301734

The following criteria were reviewed in validating the data:

1. Holding Time: All criteria met
2. GC/MS Tune: All criteria met.
3. Calibration:

Semivolatile Analysis Calibration:

Instrument T was used to perform the semivolatile analysis.  
Calibration results for this instrument is as follows:

Instrument T

Initial: 6/11/90, 1 compound, benzoic acid, has a percent relative standard deviation (%RSD) > 30%.

Impact on data: No samples were quantitated on this initial calibration.

Continuing: 6/12/90, 1 compound, benzoic acid, has a percent deviation (%D) > 25%.

Impact on data: Results for compounds which are quantitated on continuing calibrations with %D > 25% should be qualified as follows: detected compound values should be estimated for benzoic acid. The samples potentially impacted are SB4-SS3, SB4-SS3A, SB4-SS3MS, and SB4-SS3MSD. Benzoic acid was not detected in any of these samples.

Instrument Z

Initial: 6/7/90, Meets criteria.

Continuing: 6/7/90, 1 compound, 4-chloroaniline, has a percent deviation (%D) > 25%.

Impact on data: Results for compounds which are quantitated on continuing calibrations with %D > 25% should be qualified as follows: detected compound values should be estimated for 4-chloroaniline. The samples potentially impacted are MW1-GW2 and MW2-GW2. 4-Chloroaniline was not detected in any of these samples.

4. Blanks:

The intent of blank analysis results are to evaluate the potential of contamination contribution by the sampling and/or analytical process. Both field blanks and laboratory blanks are included in this data package. The compound bis(2-ethylhexyl)phthalate was detected at 53

ug/Kg in laboratory blank SBLK71. This would result in a 'considered nondetect' value of 530 ug/Kg for associated samples. It should be noted that, although this blank was extracted on the same day as the samples, this reagent blank is not the associated blank for the semivolatile extraction sequence.

5. Surrogate Spike:

Water Matrix:

Surrogate recovery windows created from EPA Contract Laboratory Program data base. All samples and field blanks for the water matrix had high acid surrogate recoveries. Due to lack of sample, reextractions were not done.

Impact on data: All positive results for the acid fraction should be considered estimated for the following samples: MW1-GW2 and MW2-GW2. No compounds from the acid fraction were detected.

Soil Matrix:

All surrogates for the reagent blank SBLK74 were less than 10%.

Impact on data: The laboratory submitted another reagent blank, SBLK71, which was extracted on the same day as the soil samples SB4-SS3 and SB4-SS3A; however, this blank was not associated with the extraction sequence of these soil samples. Although the use of SBLK71 is questionable with respect to determining contamination contribution from the extraction process, it is in the reviewers judgement that this represents an isolated occurrence and does not reflect a fundamental problem with the extraction process.

6. Matrix Spike/Matrix Spike Duplicate:

The matrix spike SB4-SS3MS had a low recovery for n-nitroso-di-propylamine. In addition, the relative percent deviations (RPDs) were noncompliant for both acid and base neutral matrix spike compounds.

Impact on data: Although this could reflect poor precision for the analytical process. It is in the reviewers judgement that there is no impact on the data.

7. Field Duplicates:

The field duplicates for the soil matrix are SB4-SS3 and SB4-SS3A. No target compounds were detected in either sample.

8. Internal Standard (IS) Performance: All criteria met.

9. TCL Compound Identification: All criteria met.

10. Compound Quantitation and Reported Detection Limits:

Instrument detection limits were not submitted. Quantitation limits were met except for reagent blank SBLK71. This reagent blank's quantitation limit should be increased by 1.053.

11. Tentatively Identified Compounds: All criteria met.

12. System Performance: All criteria met.

# ICF KAISER ENGINEERS

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TO: Claudia Brand

FROM: Jay Kuhn

DATE: July 17, 1990

SUBJECT: Arrowhead Plating Site, Data Validation, 13 Water Samples and 2 Soil Samples, Volatile Organic Analysis, Versar Inc., Virginia.

REFERENCE: Validation 9, Versar Control Number 2763 and 2769, Groundwater, Soil Boring

A level I validation was performed on the organic analytical data from 10 water samples and 2 soil samples collected at the Arrowhead Plating Site as part of the Remedial Investigation/Feasibility Study. The samples were analyzed for EPA Target Compound List (TCL) volatile organics by Versar Inc., Springfield, Virginia. Validation was performed in accordance with the EPA Functional Guidelines for Evaluating Organics Analyses (February 1, 1988). A copy of the checklist has been provided as an attachment for your information.

The samples included in the data package are the following.

MW1-GW2	MW5-GW2	MW10-GW2
MW2-GW2	MW6-GW2	MW12-GW2
Trip Blank	MW7-GW2	MW13-GW2
SB4-SS3 (10-12')	MW8-GW2	Field Blank 5
SB4-SS3A (10-12')	MW9-GW2	Trip Blank 15

## Overall Assessment of Data for Samples Evaluated:

1. In order to quantify target compounds, dilutions were done. As a result, the following samples had quantitation limits increased by the following dilution factors:

<u>Sample ID</u>	<u>Dilution Factor</u>
MW7-GW2	2
MW8-GW2	100
MW9-GW2	500
MW10-GW2	500
MW12-GW2	200
MW13-GW2	200

AR301738

2. Contrary to laboratory deliverables, the qualitative identification of the following compounds did not meet criteria. The mass ion intensity of the sample spectrum was not within 20% of the standard spectrum. Therefore, the following compounds should be qualified as tentatively identified:

Sample ID:

MW2-GW2

MW6-GW2

MW7-GW2

MW8-GW2

MW9-GW2

MW10-GW2

MW12-GW2

MW13-GW2

Target Compound:

Trichloroethene

Tetrachloroethene

Trichloroethene

Tetrachloroethene

Trichloroethene

Tetrachloroethene

1,1-Dichloroethene

Tetrachloroethene

1,1-Dichloroethene

Trichloroethene

Tetrachloroethene

Tetrachloroethene

Trichloroethene

Tetrachloroethene

AR301739

The following criteria were reviewed in validating the data:

1. Holding Time: All criteria met.
2. GC/MS Tune: All criteria met.
3. Calibration:

Instruments U and Y were used to perform the volatile analysis. Calibration results for each instrument are as follows.

#### Instrument U

Initial: 5/21/90, 1 compound, bromoform, has a relative standard deviation (%RSD) > 30%.

Impact on data: No compounds were quantitated from the initial calibration.

Continuing: 5/24/90, 2 compounds, chloromethane and carbon disulfide have a %D > 25%.

Impact on data: Results for compounds which are quantitated on continuing calibrations with percent deviation (%D) > 25% should be qualified as follows: detected compound values for chloromethane should be estimated. The samples potentially impacted are SB4-SS3 and SB4-SS3A. This compound was not detected in either sample.

#### Instrument Y

Initial: 5/22/90, meets criteria.

Continuing: 5/22/90, 6 compounds, acetone, 1,1,1-trichloroethane, 1,2-dichloroethane, vinyl acetate, bromodichloromethane, and cis-1,3-dichloropropene have a %D > 25%.

Impact on data: Results for compounds which are quantitated on continuing calibrations with percent deviation (%D) > 25% should be qualified as follows: detected compound values for acetone, 1,1,1-trichloroethane, 1,2-dichloroethane, vinyl acetate, bromodichloromethane, and cis-1,3-dichloropropene should be estimated. The samples potentially impacted are MW1-GW2 and MW2-GW2. These compounds were not detected in either MW1-GW2 or MW2-GW2.

Initial: 5/23/90, 1 compound, acetone, has a %RSD > 30%.

Impact on data: Results for compounds which are quantitated on initial calibrations with a %RSD > 30% should be qualified as follows: detected compound values for acetone should be estimated. The samples potentially impacted are MW5-GW2, MW6-GW2, MW10-GW2, MW12-GW2, MW13-GW2, MW7-GW2, Field Blank 5, and Trip Blank 15. Acetone was not detected in any of these samples.

AR301740

Continuing: 5/24/90, meets criteria.

4. Blanks:

The intent of blank analysis results are to evaluate the potential of contamination contribution by the sampling and/or analytical process. Both field blanks and laboratory blanks are included in this data package. There were no volatile compounds detected in any of the laboratory or field blanks.

5. Surrogate Spike:

Surrogate recovery windows created from EPA Contract Laboratory Program data base. All surrogate recoveries are compliant.

6. Matrix Spike/Matrix Spike Duplicate:

No matrix spike/matrix spike duplicate was done with this analytical sequence.

7. Field Duplicates:

The field duplicates are SB4-SS3 and SB4-SS3A. Methylene chloride was detected and 12 ug/Kg and 9 ug/Kg respectively with a RPD of 29%.

8. Internal Standard (IS) Performance: All criteria met.

9. TCL Compound Identification:

Qualitative identification of a target compound requires that the mass ion intensity of the sample spectrum be within 20% of the standard spectrum. This criteria for TCL identification was not met for the following compounds and corresponding samples:

Sample ID:

Target Compound:

MW2-GW2

Trichloroethene

MW6-GW2

Tetrachloroethene

MW7-GW2

Trichloroethene

Tetrachloroethene

MW8-GW2

Trichloroethene

Tetrachloroethene

MW9-GW2

1,1-Dichloroethene

Tetrachloroethene

MW10-GW2

1,1-Dichloroethene

Trichloroethene

Tetrachloroethene

MW12-GW2

Tetrachloroethene

MW13-GW2

Trichloroethene

Tetrachloroethene

Impact on data: These results will be qualified as tentatively identified.

AR301741

10. Compound Quantitation and Reported Detection Limits:

The following dilutions occurred in order to quantitated target compounds within the range of the initial calibration:

<u>Sample ID</u>	<u>Dilution Factor</u>
MW7-GW2	2
MW8-GW2	100
MW9-GW2	500
MW10-GW2	500
MW12-GW2	200
MW13-GW2	200

As a result of these dilutions the method quantitation limits are increased by the dilution factor for non-detected compounds.

11. Tentatively Identified Compounds: All criteria met.

12. System Performance: All criteria met.

AR301742

# **ICF KAISER ENGINEERS**

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TO: Claudia Brand

FROM: Jay Kuhn

DATE: July 17, 1990

SUBJECT: Arrowhead Plating Site, Data Validation, 9 Water Samples,  
Semivolatile Organic Analysis, Versar Inc., Virginia.

REFERENCE: Validation 10, Versar Control Number 2769, Groundwater

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A level I validation was performed on the organic analytical data from 8 water samples collected at the Arrowhead Plating Site as part of the Remedial Investigation/Feasibility Study. The samples were analyzed for EPA Target Compound List (TCL) semivolatile organics by Versar Inc., Springfield, Virginia. Validation was performed in accordance with the EPA Functional Guidelines for Evaluating Organics Analyses (February 1, 1988). A copy of the checklist has been provided as an attachment for your information.

The samples included in the data package are the following.

MW5-GW2	MW8-GW2	MW12-GW2
MW6-GW2	MW9-GW2	MW13-GW2
MW7-GW2	MW10-GW2	Field Blank 5

## **Overall Assessment of Data for Samples Evaluated:**

1. The acid fraction for sample MW8-GW2 is non-compliant due to poor surrogate recoveries. All samples results for the fraction were reported as non-detected, therefore the data for the acid fraction should be rejected.
2. Data results for 3,3'-Dichlorobenzidene in samples MW5-GW2, MW6-GW2, MW7-GW2, MW8-GW2, MW9-GW2, MW10-GW2, and MW12-GW2 should be rejected due to non-compliant continuing calibration.

**AR301743**

The following criteria were reviewed in validating the data:

1. Holding Time: All criteria met
2. GC/MS Tune: All criteria met.
3. Calibration:

Instruments T and W were used to perform the volatile analysis. Calibration results for each instrument are as follows.

#### Instrument T

Initial: 6/11/90, 1 compound, Benzoic Acid, has a relative standard deviation (%RSD) > 30%.

Impact on data: No samples were quantitated from this initial calibration.

Continuing: 6/19/90, 6 compounds, Benzoic Acid, 2-Nitroaniline, 4-Nitrophenol, 4-Bromophenyl-phenylether, Hexachlorobenzene, and Butylbenzylphthalate have a percent deviation (%D) > 25%.

Impact on data: Results for compounds which are quantitated on continuing calibrations with percent deviation (%D) > 25% should be qualified as follows: detected compound values for all 6 compounds should be estimated. The sample potentially impacted is MW13-GW2. No compounds were detected in this sample.

#### Instrument W

Initial: 6/8/90, 4 compounds, Bis(2-chloroisopropyl)ether, 4-Chloroaniline, 3-Nitroaniline, and 4-Nitroaniline have a %RSD > 30%.

Impact on data: No samples were quantitated from this initial calibration.

Continuing: 5/22/90, 2 compounds, 3-Nitroaniline and 3,3'-Dichlorobenzidine have a %D > 25%.

Impact on data: Results for compounds which are quantitated on continuing calibrations with percent deviation (%D) > 25% should be qualified as follows: detected compound values for 3-Nitroaniline and 3,3'-Dichlorobenzidine should be estimated and reject the data of 3,3'-Dichlorobenzidine when non-detected. The samples impacted are MW5-GW2, MW6-GW2, MW7-GW2, MW8-GW2, MW9-GW2, MW10-GW2, and MW12-GW2. Neither 3-Nitroaniline or 3,3'-Dichlorobenzidine were detected. The data will be qualified for the rejection of non-detect data of 3,3'-Dichlorobenzidine.

4. Blanks:

The intent of blank analysis results are to evaluate the potential of

AR301744

contamination contribution by the sampling and/or analytical process. Both field blanks and laboratory blanks are included in this data package. There were no volatile compounds detected in any of the laboratory or field blanks.

5. Surrogate Spike:

Surrogate recovery windows created from EPA Contract Laboratory Program data base. The following are non-compliant surrogate recoveries:

<u>Sample ID:</u>	<u>2-Fluorophenol:</u>	<u>Tribromophenol:</u>
MW10-GW2	10%	
MW8-GW2	11%	5%

Impact on data: Sample MW8-GW2 is non-compliant. The laboratory stated that no more sample is available to reextract. All positive results for the acid fraction for sample MW8-GW2 should be considered estimated and reject all non-detect data.

6. Matrix Spike/Matrix Spike Duplicate:

No matrix spike/matrix spike duplicate was done with this analytical sequence.

7. Field Duplicates:

No field duplicate was done for this analytical sequence.

8. Internal Standard (IS) Performance: All criteria met.

9. TCL Compound Identification: All criteria met.

10. Compound Quantitation and Reported Detection Limits:

Quantitation limits were met. Instrument detection limits were not submitted.

11. Tentatively Identified Compounds: All criteria met.

12. System Performance: All criteria met.

AR301745

# ICF KAISER ENGINEERS

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TO: Claudia Brand

FROM: Jay Kuhn

DATE: July 18, 1990

SUBJECT: Arrowhead Plating Site, Data Validation, 5 Water Samples  
Semivolatile and Volatile Organic Analysis, Versar Inc.,  
Virginia.

REFERENCE: Validation 14, Versar Control Number 2885, Groundwater,

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A level I validation was performed on the organic analytical data from 3 groundwater samples collected at the Arrowhead Plating Site as part of the Remedial Investigation/Feasibility Study. The samples were analyzed for EPA Target Compound List (TCL) volatile and semivolatile organics by Versar Inc., Springfield, Virginia. A volatile organic compounds trip blank is included in this analytical sequence. Validation was performed in accordance with the EPA Functional Guidelines for Evaluating Organics Analyses (February 1, 1988). A copy of the checklist has been provided as an attachment for your information.

The samples included in the data package are the following.

MW3-GW2	MW4-GW1	MW11-GW1	Field Blank
			Trip Blank

Note: Sample MW4-GW1 and MW11-GW1 were incorrectly designated MW4-GW2 and MW11-GW2 on the field chain-of-custody. These samples are first round groundwater samples; therefore, with respect to data summaries and validations they will be designated MW4-GW1 and MW11-GW1.

## Overall Assessment of Data for Samples Evaluated:

1. The detected values of methylene chloride in MW4-GW1, MW11-GW1, and MW3-GW2 should be considered non-detected.
2. For the semivolatile analysis of MW11-GW1 no surrogate compounds were detected; therefore, all non-detect data should be rejected.
3. In order to quantify target compounds, two dilutions of MW11-GW1 were done. As a result the method detection limits should be increased by a factor of 5.

AR301746

The following criteria were reviewed in validating the data:

1. Holding Time: All criteria met
2. GC/MS Tune: All criteria met.
3. Calibration:

Volatile analysis:

Instrument U was used to perform the volatile analysis. Calibration results for this instrument is as follows.

Instrument U

Initial: 6/14/90, 2 compounds, acetone and 2-butanone, have a relative standard deviation (%RSD) > 30%.

Impact on data: No compounds were quantitated from the initial calibration.

Continuing: 6/14/90, 1 compound, chloroethane, has a %D > 25%.

Impact on data: Results for compounds which are quantitated on continuing calibrations with percent deviation (%D) > 25% should be qualified as follows: detected compound values for chloroethane should be estimated. The samples potentially impacted are MW3-GW2, MW4-GW1, and MW11-GW1. Chloroethane was not detected in any of these samples; therefore, no qualification of the data is warranted.

Continuing: 6/15/90, meets criteria.

Semivolatile analysis:

Instrument Z was used to perform the semivolatile analysis. Calibration results for this instrument is as follows.

Instrument Z

Initial: 6/7/90, meets criteria.

Continuing: 6/19/90, 1 compound, 3-nitroaniline, has a %D > 25%.

Impact on data: Results for compounds which are quantitated on continuing calibrations with percent deviation (%D) > 25% should be qualified as follows: detected compound values for 3-nitroaniline should be estimated. The samples potentially impacted are MW3-GW2, MW4-GW1, and MW11-GW1. 3-Nitroaniline was not detected in any of these samples; therefore, no qualification of the data is warranted.

Initial: 6/26/90, meets criteria.

Continuing: 6/28/90, 1 compound, 2-methylnaphthalene, has a %D >25%.

Impact on data: Results for compounds which are quantitated on continuing calibrations with percent deviation (%D) > 25% should be qualified as follows: detected compound values for 2-methylnaphthalene should be estimated. No samples are impacted by this; therefore, no qualification of the data is warranted.

4. Blanks:

The intent of blank analysis results are to evaluate the potential of contamination contribution by the sampling and/or analytical process. Both field blanks and laboratory blanks are included in this data package. The maximum concentration of contamination found in any of the field, trip, or laboratory blanks is as follows:

<u>Contamination</u>	<u>Detected Concentration of Contamination</u>	<u>Contamination Considered Non-detect up to Concentration</u>	<u>Blank I.D.</u>
Methylene Chloride	6 ug/L	60 ug/L	VBLK57
Methylene Chloride	4 ug/L	40 ug/L	Field Blank
Methylene Chloride	4 ug/L	40 ug/L	Trip Blank

Impact on data: The detected values of methylene chloride in MW4-GW1, MW11-GW1, and MW3-GW2 should be considered non-detected.

5. Surrogate Spike:

Surrogate recovery windows created from EPA Contract Laboratory Program data base. All surrogate recoveries were compliant for the volatile organic analyses. All surrogate recoveries were compliant for the semivolatile organic analyses except MW11-GW1 in which all surrogates were non-detect. This is likely a result of not spiking surrogate compounds into the sample.

Impact on data: No target compounds were detected; therefore, all non-detect data should be rejected.

6. **Matrix Spike/Matrix Spike Duplicate:** No matrix spike/matrix spike duplicate was done with this analytical sequence.
7. **Field Duplicates:** No field duplicates were done with this analytical sequence.
8. **Internal Standard (IS) Performance:** All criteria met.
9. **TCL Compound Identification:** All criteria met.

10. Compound Quantitation and Reported Detection Limits:

Instrument detection limits were not submitted. In order to quantify target compounds, two dilutions of MW11-GW1 were done. As a result the method detection limits should be increased by a factor of 5.

11. Tentatively Identified Compounds: All criteria met.

12. System Performance: All criteria met.

# ICF KAISER ENGINEERS

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TO: Claudia Brand

FROM: Davida Parker Trumbo

DATE: July 12, 1990

SUBJECT: Arrowhead Plating Site, Data Validation, 2 Soil and 4 Water Samples for Inorganic Analysis, Versar Inc., Control No. 2763

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A data validation was performed on the inorganic analytical data from 2 soil and 4 water samples collected at the Arrowhead Plating Site as part of the remedial investigation/feasibility study. The samples were analyzed in accordance with EPA Contract Laboratory Program protocols for cyanide and in accordance with SW-846 protocols for the following metals:

Aluminum	Chromium	Mercury	Sodium
Barium	Copper	Potassium	Zinc
Calcium	Iron	Nickel	
Cadmium	Lead	Silver	

The data was validated in accordance with quality control criteria established in the noted analytical methods. A copy of the checklist used to record the specific observances has been provided for your information as an attachment to this report.

samples in this data package included:

MW1-GW2	MW2-GW2	SB4-SS3
MW1-GW2 F	MW2-GW2 F	SB4-SS3A

**Overall Data Assessment:** The overall laboratory performance met quality control criteria with the following exceptions:

1. Cyanide samples were analyzed approximately 25 days after sample collection. The detection limits for this analyte should be considered elevated, indicating the potential for false negatives. Results for MW1-GW2 and MW2-GW2 should be rejected, and soil boring sample results should be considered approximate.
2. Silver results are rejected for all monitoring well samples due to poor recoveries associated with the matrix spike. The potential for false negatives exists due to elevated detection limits.
4. Nickel and potassium results in the water samples and copper results in soil samples should be approximated due to variances associated with the laboratory duplicate analysis.
5. Calcium, chromium, nickel, sodium, and zinc duplicate results in samples SB4-SS3 and SB4-SS3A exhibited significant variances. This could be attributable to several factors including the non-homogeneity of the sample. Results for the analytes in these samples may therefore be viewed as approximate.

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6. Sodium and zinc results are approximated in soil boring samples SB4-SS3 and SB4-SS3A due to chemical or physical interferences associated with the ICP analysis.

The following criteria were reviewed during the data validation:

1. **Holding Times:** All criteria were met with the exception of cyanide which was analyzed after the recommending holding period of 14 days. Cyanide results for water samples should be rejected and soil boring results should be considered approximate.
2. **Initial and Continuing Calibration Verification:** All criteria met.
3. **Blank Analysis:** All criteria were met.
4. **ICP Interference Check Sample:** All criteria were met.
5. **Matrix Spike Sample Analysis:** The spike recovery for MW1-GW1 was 9% and suggests accuracy problems. The results for silver in all water samples should be rejected due to the potential for false negatives. All criteria were met for soil boring samples.
6. **Laboratory Precision Evaluation:** All criteria were met for water samples with the exception of nickel and potassium. The results for these analytes should be approximated in all samples. All criteria were met for soil samples with the exception of copper suggesting that all soil samples be approximated for that analyte.
7. **Field Precision Evaluation:** Duplicate samples were collected for soil boring samples and large variances between sample results were obtained for the following analyte: calcium, chromium, nickel, sodium, and zinc. The results for these analytes may be considered approximate.
8. **Laboratory Control Sample:** Metals were analyzed by SW-846 methods which do not specify the evaluation of laboratory control samples, but the laboratory submitted the appropriate form and all analytes were in control. Since cyanide was processed using contract laboratory program (CLP) protocols the results were evaluated and determined to be in control.
9. **Standard Additions/Furnace Atomic Absorption Analysis (GFAA):** All criteria were met.
10. **Serial Dilution Results:** All criteria were met for the water samples. Sample results should be approximated for sodium and zinc results in the soil boring samples due to chemical or physical interferences encountered during ICP analysis. approximated for these analytes in the samples.

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